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II

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Internet Traffic Zone Identification by Backpropagation and Probabilistic Neural Networks

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Abstract. **The article proposes an approach based on the concept of Artificial Intelligence for the categorization of urban areas of Internet content by corporate customers. The applicability of different neural apparatus was analyzed as well as three-layer Backpropagation Neural Networks (BPN) and four-layer Probabilistic Neural Networks (PNN) as the most suitable for the purpose of the study were selected. The synthesis of BPN architectures for Internet traffic identification was carried out according to a different number of computing units in the hidden layers with hyperbolic tangent sigmoid, log-sigmoid and linear transfer functions. The variations of a set of specific criteria were examined as Accuracy, Mean-Squared Error, Mean Absolute Error, Correlation coefficients, etc. The selection of PNNs against the defined quality indicators was based on a stepwise increase of the spread indicator of the Kernel functions in a Radial-Basis (RB) structural layer by analogy similar to that applied to BPNs. In the research processes, high levels of neural recognition indicators were established in processing with the Incoming flows of Internet Packages in an Accuracy of over 90.00%.**

Keywords: accuracy, backpropagation, probabilistic, traffic identification.

I. INTRODUCTION

The analysis of transmitted and serviced traffic in the global Internet network and ICT systems in relation to content consumption, optimization of transmission environment parameters and maintenance of QoS are important aspects of planning in modern communications. As tools for such procedures, a variety of Analytical Techniques, Methods, and Algorithms from "Artificial Intelligence" and "Machine Learning" concepts are applied [1, 2].

A substantial part of the research and development concerns the applicability of Convolutional Neural Networks (CNNs) and Recurrent Neural Networks based on deep learning techniques. The main subjects of research are HTTP and SIP communications flows in connection with IoT traffic service [3]. CNN structures are often successfully used in connection with network traffic measurements for specific parameters such as throughput, packet sizes, times of receipt and release of user requests, repeatability in IP addressing addresses and ports, [4, 5] etc. RNN models can be useful in connection with the classification of encrypted traffic via FTP, HTTP, VoIP, XMPP and other protocol services in wireless sensor networks [6]. The combination of CNNs and Long Short-Term Memory (LSTM) when operating on VPN platforms allows for the effective identification of encrypted traffic content, including voice data, images and other formats [7]. In [8], an approach combining Deep Neural Networks (DNN) with k-Nearest Neighbors (k-NN) and Support Vector Machine (SVM) solves various security monitoring and intrusion detection tasks regarding networks and network segments of IoT devices. Deep Learning Techniques, including Multi-Layer Perceptrons (MLPs), CNNs, RNNs, Generative Adversarial Networks (GAN), etc., are widely used in the classification of encrypted content in relation to well-known Google Applications [9]. Bayesian Neural Networks is a neural apparatus that meets the requirements of network operators in connection with the identification of anomalies in the transmission of traffic packages [10].

The article sets the task of categorizing the regions of consumption of Internet traffic by business companies in active time zones in an urban area with the help of

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Artificial Intelligence. The identification procedures are based on basic traffic parameters, respectively:

- Flows;
- Mean packet size in IPv4;
- Mean packet size in Ipv6;
- Mean packet transmission.

Systematized is a combined approach with the integration of Backpropagion Neural Networks and Probabilistic Neural Networks for analysis, evaluation and selection of models and categorization apparatus.

II. Meterial and Methods

The first phase of the research consists in the training and selection of Feed-Forward Neural Networks with Backpropagation learning processes. The training procedures are based on the Levenberg-Marquardt algorithm. The adequacy analysis of the selected neural apparatus on the classification task is based on the concept of different types of activation of the output layers of the BPN architectures and discrete code combinations to define the classification groups. In this case, neural models for identification of geographic zones of Internet content consumption were considered with:

- Linear activation type or "purelin";
- Hyperbolic tangent sigmoid transfer function or "tansig";
- Log-sigmoid activation type or "logsig".

The second phase of the research is aimed at assessing the quality of synthesized Backpropagation Neural Networks about performance analysis.

The final phase of the activities of the selection of neural apparatus and model for categorization of urban regions of Internet consumption is expressed in the assessment of the behavior of the Probabilistic Neural Networks. The architecture of the basic PNN model has been built by Input, Radial Basis, Competitive and Output Layers. By definition, the overall research framework for PNNs provides:

- constant state of neurons in the Radial Basis layer;
- lack of separation of phases of creation and training of neural models;
- change the "Spread" indicator on structural Kernel functions.

III. Results and Discussion

Traffic Zone Identification Using Feed-Forward Neural Networks with Backpropagation

The results of the quality assessment of the defined BPNs types for the criteria applied: 1) Accuracy, 2) Mean-Squared Error and 3) Mean Absolute Error are set out in Table 1 to Table 3.

Table 1 Results at BPN Selection Procedures in "purelin" Output Transfer Function

Hidden Neurons	Quality Indicators		
	Accuracy, %	***MSE***	***MAE***
3	91.3	0.0736	0.1653
4	95.7	0.0581	0.1149
5	95.7	0.0380	0.1276
6	95.7	0.0427	0.0577
7	95.7	0.0287	0.1050
8	100.0	0.0726	0.2123
9	95.7	0.0550	0.1345
10	95.7	0.0246	0.0963
11	95.7	0.0517	0.1783
12	87.0	0.1148	0.2150
13	95.7	0.0457	0.1218
14	100.0	0.0328	0.1327
15	100.0	0.0138	0.0970
16	100.0	0.0220	0.1096
17	91.3	0.0869	0.2292
18	95.7	0.0524	0.1297
19	91.3	0.0747	0.1982
20	95.7	0.0371	0.1412

In relation to the linear type of output activation, 95.7% accuracy was observed for the predominant of the created neural models. This fact applies to BPN structures with 4 to 7, 9-11, 13, 18 and 20 neurons in hidden layers. The mean squared error falls within the established range of 0.0138 for a network with 15 to 0.1148 about the categorization model containing 12 hidden neurons. While the MEA indicator registered a minimum of 0.0577 and a maximum of 0.2292 variations for the cases of BPNs at 6 and 17 neurons in structural hidden layer. Correct recognition of target samples from the input information set was achieved in neural architectures with a set amount of computational units in the hidden layer from 14 to 16. In view of the minimum MSE criteria requirement, it was identified as the best Backpropagation network with the presence of 15 hidden neurons.

Table 2 Results at Syntresis processes of BPNs in "tansig" Output Activation Type

Hidden Neurons	Quality Indicators		
	Accuracy, %	***MSE***	***MAE***
3	91.3	0.0904	0.1219
4	91.3	0.0912	0.1810
5	78.3	0.1371	0.2544
6	95.7	0.0321	0.0718
7	87.0	0.1308	0.1367
8	100.0	0.0040	0.0479
9	91.3	0.0532	0.0766
10	87.0	0.1149	0.1589
11	95.7	0.0468	0.1067
12	91.3	0.0762	0.1301

Hidden Neurons	Quality Indicators		
	Accuracy, %	*MSE*	*MAE*
13	91.3	0.0671	0.1727
14	95.7	0.0506	0.0973
15	95.7	0.0436	0.0481
16	95.7	0.0466	0.1168
17	95.7	0.0435	0.0439
18	82.6	0.1188	0.2146
19	95.7	0.0191	0.0557
20	91.3	0.0692	0.0827

With a view to the applied Hyperbolic tangent sigmoid output type of the activations, the following accuracies were found:

- low levels below 90.0%, respectively,82.6 % at 18, followed by 87.0 % for BPNs in 7 and 10 hidden neurons;
- 91.3% for neural architectures involving 3, 4, 9, 12, 13 and 20 neurons in the interlayer;
- equal to the previous level in terms of the number of neural structures, 95.7% for networks with fixed 6, 11, 14, 15, 16 and 17 hidden computing units;
- single accounted highest accuracy level of 100.0 % for a BPN model with 8 intermediate neurons.

In contrast to the previous BPN type studied, for the model with a correct classification of all samples, minimum readings of the basic MSE and MAE indicators, respectively 0.0040 and 0.0479 were established. Here, the errors recorded are significantly lower than their equivalents in architectures with a "purelin" output transfer function, determining the higher degree of suitability of the "tansing" activation type. The highest values of the indicated indicators MSE = 0.1371 and MAE = 0.2544 were found BPNs with 5 for the neural model with the lowest degree of recognition quality with Accuracy, which is equal to only 78.3%.

TABLE 3 RESULTS FOR BPNS SELECTION IN "LOGSIG" OUTPUT TRANSFER FUNCTION

Hidden Neurons	Quality Indicators		
	Accuracy, %	*MSE*	*MAE*
3	95.7	0.1431	0.2973
4	91.3	0.1672	0.3488
5	91.3	0.1684	0.2943
6	100.0	0.1358	0.2863
7	91.3	0.1558	0.2979
8	91.3	0.1590	0.3066
9	78.3	0.1825	0.3256
10	91.3	0.1663	0.3256
11	91.3	0.1471	0.3066
12	78.3	0.1929	0.3381
13	87.0	0.1968	0.3294
14	91.3	0.1660	0.3150
15	100.0	0.1326	0.2788
16	82.6	0.2097	0.3426
17	95.7	0.1439	0.2771
18	95.7	0.1478	0.2786
19	100.0	0.1293	0.2729
20	100.0	0.1337	0.2803

According to the used Log-sigmoid transfer function, a trend of similar levels of accuracy was found, but at times higher variations of MSE and MAE criteria. The Mean-Squared Error does not fall below 0.1200, and the Mean Absolute Error falls below 0.2700. Their minimum variations of 0.1293 and 0.2793 were reported for the neural structure with the highest rating of classification quality - accuracy 100.0%, at 19 hidden neurons. The highest error rates MSE = 0.2097 and MAE = 0.3488 were reached in BPNs in the composition, which were 16 and 4 neurons in the intermediate network layer. The analysed results give grounds for the considered neuron type to be categorized with the lowest degree of adequacy with regard to the assigned classification task.

Performance Analysis of BPN models for Internet Traffic Zone Categorization

The selected structural models for traffic identification in sequential setting of linear, hyperbolic tangent sigmoid and log-sigmoid neural activation of the output layers are given in Fig. 1.

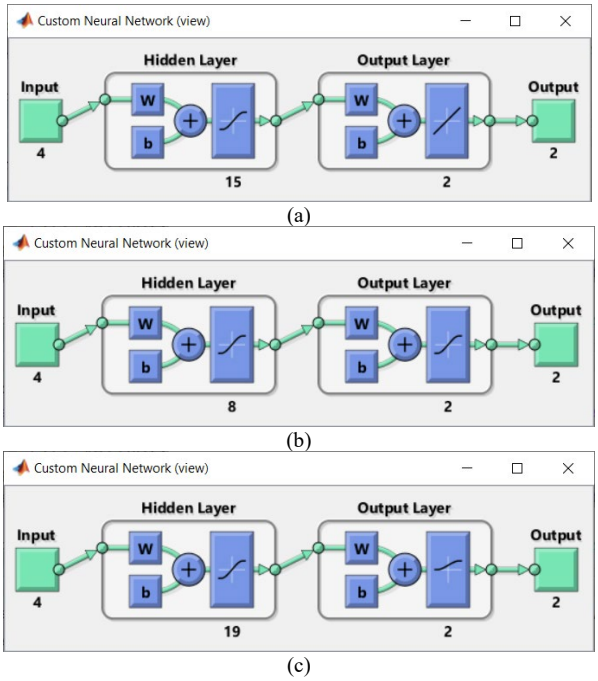
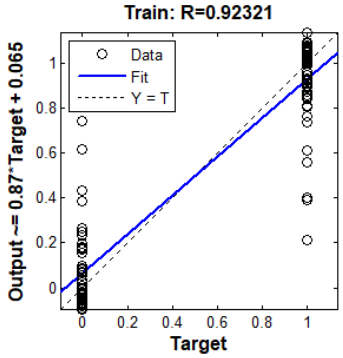
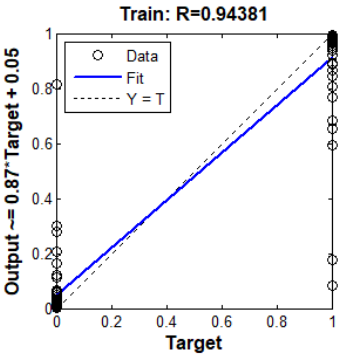


Fig. 1. Synthesized BPN architectures for Internet traffic zone categorization in (a) "purelin", (b) "tansig" and (c) "logsig" output activation types.

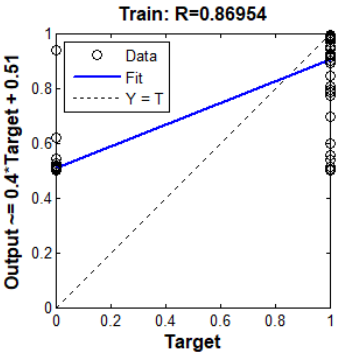
Regression diagnostic activities were carried out against the main network processes of training, validation and testing. Those procedures shall cover 70%, 15 % and 15 % of the volume of the input information sample. The linear regression dependencies for the state of network training generated for the selected BPNs are presented in Fig. 2. A good approximation of the theoretical and empirical regression lines can be seen against the "purelin" and "tansig" activation types. While the neuron model with a fixed Log-sigmoid transfer function (Fig. 2.(c)) shows a significant deviation, another significant sign of deterioration in the quality of the considered BPN is the underestimation of the correlation factor R below the threshold of 0.9000. Quantitative indicator levels R = 0.92321 for "purelin", R = 0.94381 at "tansig" and R = 0.86954 in "logsig" activations were reported, showing the best qualities of the second applied output activation.



(a)



(b)

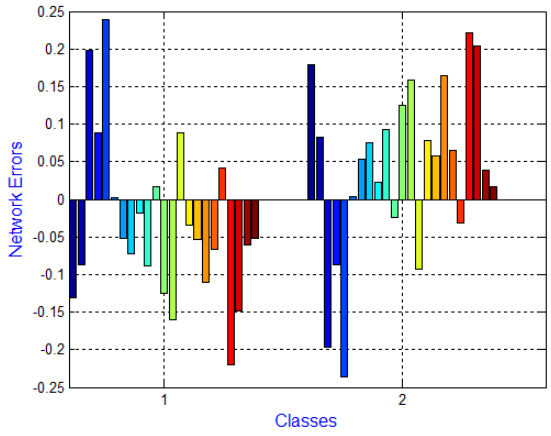


(c)

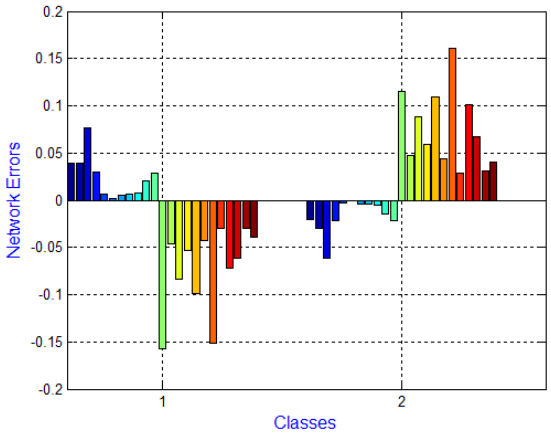
Fig. 2. Linear regression dependences for the learning process for selected BPNs for Internet traffic zone categorization in (a) "purelin", (b) "tansig" and (c) "logsig" output activation types.

TABLE 4 REGRESSION COEFFICIENTS ABOUT OUTPUTS OF SELECTED BPNS FOR TRAFFIC ZONE

Network Output	Transfer Function		
	purelin	*tansig*	*logsig*
	R Indicator		
1 (Zone 1)	0.93475	0.93894	0.90516
2 (Zone 2)	0.93725	0.93927	0.9359



(a)



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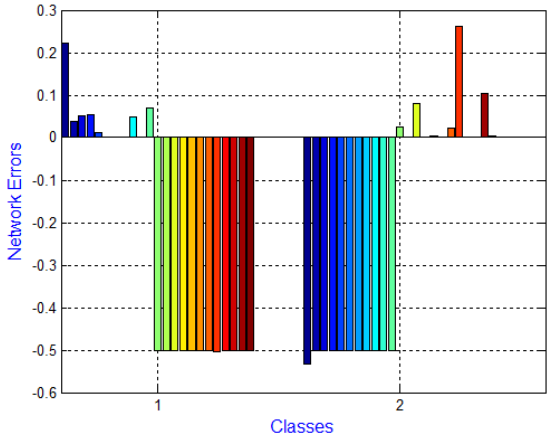

(c)

Fig. 3. Network error diagram for selected BPN models for Internet traffic zone categorization in (a) "purelin", (b) "tansig" and (c) "logsig" output transfer functions.

A similar trend regarding the lower suitability of the Log-sigmoid model is particularly confirmed for the first category zone of Internet consumption (Table 4). Here R reaches 0.90516 compared to levels around 0.9300 for linear and close to 0.9400 for hyperbolic tangent type. Compared to the second target class, minimal differences were registered, falling within the range of 0.9355 to 0.9330. The indicated data from the analysis of the relationship between the target and the output results from the use of neural models show an advantage of BPN in "tansig", followed by the one with "linear" and lastly of the network with fixed "logsig" output type.

The established qualities of the models are confirmed by the diagrams of network errors (the differences between the desired and the results calculated with the attached BPN) of Fig. 3. In the first two activation types of neural outputs, satisfactory levels below the 0.5000 limit were achieved. Ranges "-0.2358 to 0.2392" and "-0.1575 to 0.1614" have been established in relation to the use of linear and hyperbolic tangent sigmoid transfer functions. In the course of the study, levels were significantly higher than those recorded in the previous two types of models below the negative threshold of "-0.5000" with a maximum peak of "-0.5339" for a large part of the data from the composition of the test subset. The maximum observed upper threshold of network error at BPN with Log-sigmoid is "0.2627", commensurate with the "purelin" activation.

Traffic Zone Identification with Probabilistic Neural Networks

The main PNN model in connection with geraral investigation procedures is given in Fig. 4. Regarding the selection processes, an assessment of the MSE and MAE criteria was performed with a step increase of the Spread in the range from 0.05 to 0.90.

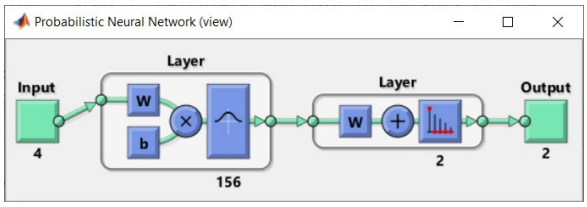

Fig. 4. PNN model for identification of Internet traffic zones.

In the initial range to a level around "0.20", the registered error levels were found to be in the range of "10-5" degree (significantly higher compared to those registered with BPN architectures). A gradual increase in the Mean-Squared Error and Mean Absolute Error indicators was observed, reaching approximate levels of "0.0060" and "0.0500" at the end of the Spread range. As a result of the overall analysis, a probabilistic neural model was selected when setting Spread = 0.10 with respect to the Radial Basis structural layer.

Figure 5 presents the distribution of the samples forming the input information set in relation to the classification procedure for each output group. There is a correct determination of the group affiliation of the test data - 100.0% levels have been obtained for Sensitivity, Precision and Accuracy indexes.

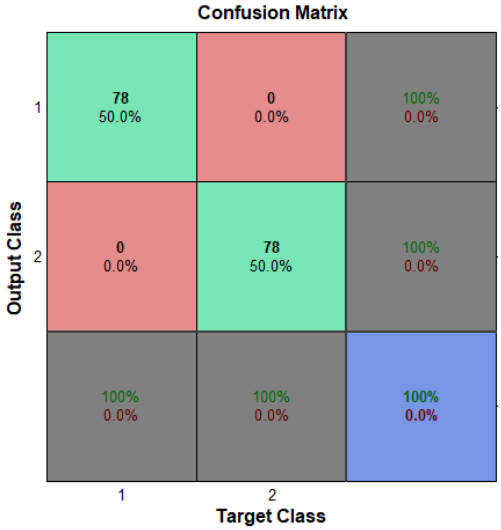

Fig. 5. Confusion matrix about PNN architectures in Internet traffic zones identification.

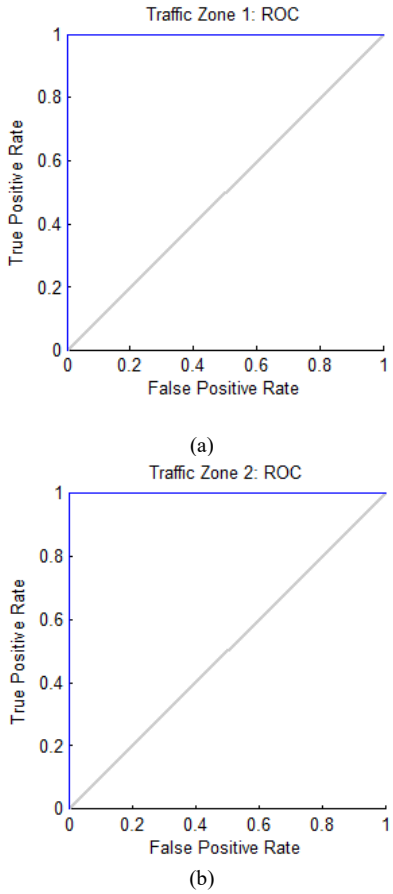

Fig. 6. ROC dependencies for PNN outputs in Internet traffic zone categorization – (a) class № 1 and (b) class № 2.

IV. CONCLUSION

In view of the aggregated results, the proposed approach to categorizing Internet traffic using BPNs and PNNs shows good applicability. In this case, an advantage of probabilities over neural structures with reverse propagation of the error has been established. Synthesized models should be embedded in ICT traffic monitoring units supporting the activities of system administrators. In the next phase of the research, activities are set for adapting models and optimization procedures in relation to predictive analysis in traffic distribution planning.

Acknowledgments

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Invasion of Information Systems as a Danger for Human Rights

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Abstract. **In recent years, more and more people have been pushed to direct usage of various information systems (IS) developed by governmental, commercial, municipal, and non-governmental organisations. IS were widely used already for a relatively long time – 2 or 3 decades (depending of state), however, people were not pushed to use them directly, they were used by staff members of organisations, so for clients it does not made a difference, do they use an IS or, for example, a paper folder or a file cabinet. Now people are increasingly required to use ISs directly, which makes the process more challenging and potentially dangerous. This article aims to analyse this situation and these processes, trying to classify risks, draw conclusions and provide recommendations.**

Keywords: human rights, information system, public service, society.

I. DEFINITION

There are different ways to define what an information system is – it can be based on understanding of data input and output,

> *Под* ***системой*** *понимают любой объект, который одновременно рассматривается и как единое целое, и как объединенная в интересах достижения поставленных целей совокупность разнородных элементов. Системы значительно отличаются между собой как по составу, так и по главным целям.*
>
> ***Информационная система*** *- это система, осуществляющая: получение входных данных; обработку этих данных и/или изменение собственного внутреннего состояния (внутренних связей/отношений); выдачу результата либо изменение своего внешнего состояния (внешних связей/отношений).*
>
> ***Простой*** *информационной системой назовем систему, элементы которой функционируют в соответствии с правилами, порожденными одним и тем же взаимонепротиворечивым множеством аксиом.*
>
> ***Сложной*** *информационной системой назовем систему, которая содержит элементы, функционирующие в соответствии с правилами, порожденными отличными друг от друга множествами аксиом. При этом допускается, что среди правил функционирования различных элементов могут быть взаимопротиворечивые правила и цели.* [1]

of organisation of social processes,

> ***sistema de información*** *Componentes interrelacionados que trabajan en conjunto para recolectar, procesar, almacenar y diseminar información para soportar la toma de decisiones, la coordinación, el control, el análisis y la visualización en una organización.* [2]

work with information

> *EN* ***information system*** *LV* ***informācijas sistēma*** *RU* ***информационная система*** *Iekārtu, procedūru un personāla kopums, kas ir izveidots, strādā un tiek uzturēts, lai vāktu, uzkrātu, apstrādātu, uzglabātu un izmantotu informāciju.* [3]
>
> *Un* ***système d'information*** *(SI) est un ensemble organisé de ressources (matériels, logiciels, personnel, données et procédures) qui permet de collecter, regrouper, classifier, traiter et diffuser de l'information sur un environnement donné.* [4]

etc. It means IS is a broad term, that can include, for example, computer networks, the Internet, local databases and even a personal computer with a text editor. Of course, for our purposes we are not looking so widely, because our main gain is to analyse social processes and problems initiated by wide-spreading of ISs, thus, a local, personal usage is out of range of our interest and we will focus on its social implications rather than its technical aspects.

However, for us a formal definition is not so important, since in this article we look on this term more informally, from a user's point of view instead of a

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professional's one. People see this term more narrowly, because associate it with just the ISs they are using directly and communicating with or via. We will follow this slangy practice and say that IS is a complex of software and data (Of course, some kind of hardware is used by it too, however, in most cases the level of hardware is not directly visible and accessible for end users, so that's why we don't include it in our definition.) controlled by somebody and directly used by a non-empty set of users, where the software has an human-accessible interface and the users are humans.

II. The Social Role

The social role of ISs was evolved over time as their technical capabilities and accessibility have grown together with the grow-up of information technology at all: from partial usage in book-keeping in the 1950 [ties] to all-level usage inside organisations in the 1990[ties]:

> *Первые информационные системы появились в 50-х гг. В эти годы они были предназначены для обработки счетов и расчета зарплаты, а реализовывались на электромеханических бухгалтерских счетных машинах. Это приводило к некоторому сокращению затрат и времени на подготовку бумажных документов.*
>
> *60-е гг. знаменуются изменением отношения к информационным системам. Информация, полученная из них, стала применяться для периодической отчетности по многим параметрам. Дня этого организациям требовалось компьютерное оборудование широкого назначения, способное обслуживать множество функций, а не только обрабатывать счета и считать зарплату, как было ранее.*
>
> *В 70-х - начале 80-х гг. информационные системы начинают широко использоваться в качестве средства управленческого контроля, поддерживающего и ускоряющего процесс принятия решений.*
>
> *К концу 80-х гг. концепция использования информационных систем вновь изменяется. Они становятся стратегическим источником информации и используются на всех уровнях организации любого профиля. Информационные системы этого периода, предоставляя вовремя нужную информацию, помогают организации достичь успеха в своей деятельности, создавать новые товары и услуги, находить новые рынки сбыта, обеспечивать себе достойных партнеров, организовывать выпуск продукции по низкой цене и многое другое.* [1]

Strange that in such a new book the author stops with this period. We see and would like to add three more of them.

2000[ties]: instead of local applications connected via local networks, Web-based intranet systems became wide-spread in many organisations.

2010[ties]: optional ISs of public services became widely used by many (most? – depends on country) people.

2020[ties]: many ISs of public services became compulsory instead of optional.

It is the last period that initiated the topic of this article, thus, we want to talk more and deeper about it.

III. The Problem

The changes that have transformed ISs from corporate instruments to mass-used technologies are more significant than any changes that happened in the previous half-century. A usage of ISs by professionals, who has a choice to work or not to work at this job, is one case, even these technologies are very different. A usage by a private person, if this person has a choice to use or not to use, i.e., there are alternative ways, how this person can do what he needs – is a principally different situation, but still with a possibility of choice. A usage by any person (or at least by any citizen or any client), without any alternative means of accomplishing the same tasks, constitutes digital coercion, and it raises questions about violations of human rights.

IV. Examples

We will provide some local examples from Latvia, as we have more experience with Latvian institutions and the conference for which this article is being prepared will be held in Latvia.

1. Banking. The majority of banking services in Latvia are provided by private companies registered in Latvia or other states of the European Union, as well as by one governmental organisation, the Treasury of the Republic of Latvia. Since the pandemic of coronavirus began, the Treasury has provided services only remotely:

> *Valsts kase arī turpmāk pakalpojumus sniegs tikai attālināti.* [5]

Private banking services are still available in person too, however, a comparison of prices

> ***Eiropas maksājumi*** *Uz citu banku Latvijā vai uz Eiropas maksājumu zonas valsts Ekonomiskais 16:00* ***Internetbankā*** *0,36* ***Filiālē/TB*** *5,00* [6]

shows that they are made so high especially, which appears to be an effort to discourage clients from using in-person services at all.

As a result, people are increasingly pushed to use banking via ISs, using both administrative and financial pressure.

2. Tax inspection. Changes to the Law on Taxes and Fees, accepted by the Latvian parliament in 2021, but initiated, off course, by the Inspection itself, require that all communication with the Tax Inspection be electronic,

> *No nākamā gada iesniegumus Valsts ieņēmumu dienestam (VID) nodokļu administrēšanas jautājumos nodokļu maksātāji varēs iesniegt tikai elektroniski. To noteic Saeimā galīgajā lasījumā pieņemtie grozījumi nodokļu un nodevu likumā ...* [7]

as the Inspection seeks to transition from paper to electronic communication – around 18% of declarations were on paper in previous years.

> *VID statistika liecina, ka ik gadu apmēram 18% no gada ienākumu deklarācijām tiek iesniegtas papīra veidā, un to atbilstoša apstrāde VID 2017. gadā izmaksājusi vairāk nekā divus miljonus eiro, norādīts anotācijā.* [7]

However, even in 2023, the Tax Inspection acknowledges that municipalities will assist in submitting declarations in person or that the Inspection will accept paper submissions by snail mail if individuals have no other means of submitting them.

> *Valsts un pašvaldību vienotajos klientu apkalpošanas centros (VPVKAC) ir pieejams arī jauns e-pakalpojums "Gada ienākumu deklarācijas pieņemšana". Tas paredzēts cilvēkiem, kuriem pašiem nav pietiekamu prasmju vai pieredzes EDS lietošanā. Lai saņemtu šo e-pakalpojumu, cilvēkam jāierodas kādā no VPVKAC un jāaizpilda atļauja jeb speciālpilnvara konkrētā pakalpojuma pieteikšanai. Tādējādi pats klients nekļūst par EDS lietotāju, bet klienta vārdā šo pakalpojumu, proti – Gada ienākumu deklarācijas iesniegšanu EDS, veic pilnvarotais VPVKAC darbinieks.*
>
> *Un tikai gadījumā, ja cilvēkam nav nevienas no minētajām iespējām, gada ienākumu deklarācijas veidlapas joprojām var izdrukāt VID tīmekļvietnē, aizpildīt un nosūtīt VID pa pastu ...* [8]

It would be a good example, how to give people a choice in practice, if such a bad edition of the law would not have been passed.

3. Rural Support Service. This institution has played a significant social role since 2004, when EU subsidies for farmers were first introduced. As many families in the countryside rely on this cantor for financial support, it is crucial for their livelihood. Since 2016, they only accept area payment applications via their online IS.

> *Lauku atbalsta dienests (LAD) informē, ka, sākot ar šo gadu, pieteikties uz platību maksājumiem varēs tikai elektroniski, izmantojot LAD Elektroniskās pieteikšanās sistēmu (EPS).* [9]

Now, they are starting to request to send photos of fields via their mobile application.

> *Vēstule satur norādes par fotogrāfiju uzņemšanu un iesūtīšanu Lauku atbalsta dienesta mobilajā lietotnē, ja plāno pieteikties Ekoshēmām saistībā ar augsnes kaļķošanu, minimālo augsnes apstrādi, minerālmēslu precīzo izkliedi vai augu aizsardzības līdzekļu precīzo izsmidzināšanu.* [10]

Fig. 1. Picture from the homepage of Rural Support Service. The last button of their mobile application is "Ziņot par pārkāpumu" – anybody is welcomed to become a snitch. [11]

The transition from paper maps to electronic ones had both advantages and disadvantages, so people remained more or less in balance. However, the invention of the mobile application appears very concerning, both due to the disproportionate time it may consume and the extent of personal data tracking.

4. Latvian National Centre for Culture. This institution is responsible for organising nationwide culture events, including the Song and Dance Festival (a tradition borrowed by Latvians from Germans, including local ones, in the XIX century). In previous years, registering participants by printed forms was not a problem. However, in 2023 the institution decided to use an IS for the first time to register all participating groups and their members. They started to require group managers to input all information about their groups via an online form

> *Straujiem soļiem tuvojas XXVII Vispārējie latviešu dziesmu un XVII deju svētki un lai veiksmīgi paveiktu Svētku reģistrācijas procesu, lūgums Jums aizpildīt pielikumā pievienoto piekrišanas dokumentu personas datu apstrādei, lai mēs no savas puses varētu reģistrēt Jūsu māksliniecisko kolektīvu sistēmā, kurā tālāk Jūs kā kolektīva vadītājs (vai administratīvais pārstāvis) varēsiet reģistrēt sava kolektīva dalībniekus.* [12]

and to require members to input individual information (including photos) personally via their mobile application.

> *Līdz 19. martam aicinām reģistrēties XXVII Vispārējo latviešu Dziesmu un XVII Deju svētkiem! Lejupielādē bezmaksas mobilo lietotni Dziesmusvētki savā viedierīcē (telefonā vai planšetē), ievadi tajā savu mobilā telefona numuru un aktivizācijas kodu.* [13]

While they currently deny other full-valued registration possibilities, there is a small possibility that they will change it at the last moment – before July 2023.

This situation unfortunately indicates that the management of this governmental culture organisation does not understand the human rights aspects of being a part of nationwide culture processes, even in cases where individuals may not have or not want access to modern information technology and devices.

V. Potential Violations

As we see, this invasion of ISs has the high potential to violate fundamental rights, including:

1. The right to participate in social processes in a traditional form without using information technology.

2. The right not to spend private time doing bureaucratic tasks that should be performed by bureaucracy itself.

3. The right to provide answers in a free form rather than selecting from pre-written options.

4. Increase of risk of data security in comparison to storing data on paper, including hacking, stealing, and copying of users' private data.

5. Increased risk of unsolidarity, snitching and other similar forms of negative social behaviour.

VI. Other Opinions

Researchers and Human rights organisations (HROs) are widely publishing reports on the increasing danger of human rights violations in digital age, warning that societies do not yet have mechanisms necessary to prevent such violations.

> *Concern is growing that governments' commitment to their human rights obligations is increasingly tenuous in this era of disruption. In a very short period of time, digital technology has transformed both the means through which human rights are exercised, and the means through which human rights are violated around the globe. Yet, an understanding of how to protect human rights in the digital context is significantly underdeveloped.* [14]

Lists of potential digital vulnerabilities of human rights have also been indicated.

> *... we shift from conceptual to concrete real world challenges, to explore the various ways digital technology may negatively affect actual enjoyment of human rights ... The Digital Divide ... Digitally Facilitated Repression ... Violations in the Name of Security ... Systemic Cyber Vulnerability and Digital Insecurity* [16]

The human rights problems initiated by the impact of digital technologies can also be indirect, and this lack of visibility makes them even more dangerous.

> *... pursue human rights challenges indirectly and tangentially: digital technologies do not necessarily raise human rights questions as their most compelling problems, but their impact upon the enjoyment of human rights are more subtle and pervasive. In other words, the human rights impact of digital technologies may be both secondary and second-order.* [17]

These issues have been analysed even at the level of the United Nations,

> *Digital technologies provide new means to advocate for, defend, and exercise human rights and affect all types of rights - civil and political, as well as cultural, economic and social rights. They shape how people access and share information, form their opinions, debate, and mobilise – they have deeply transformed the "public square". But they are equally used to suppress, limit and violate rights, for instance through surveillance, censorship, online harassment, algorithmic bias and automated decision-making systems. The misuse of digital technologies also disproportionately affects marginalized individuals and groups, leading to inequality and discrimination - both online and offline.* [15]

although there is no indication that local bureaucracy follows any of the UN's recommendations.

From a social perspective, it is clear that digitalisation is dangerous and should be controlled from the point of view of human rights. However, significant effort is necessary to push such mechanisms to start working.

> *Digitalisation essentially provides the infrastructural basis for power, coercion, manipulation to flow. As long as the aim of human rights is oriented towards stemming such excesses, it has a role to play in the implementation and deployment of digital technologies. But, as the different challenges made visible from the system, network and distributor or dissipater perspectives make clear, there is significant work that needs to be done before human rights law mechanisms will be fit for purpose.* [17]

VII. Conclusions

Information systems (ISs) represent one of forms of digital disruption to human rights. They may be more acutely felt by individuals because they directly affect them, rather than operating through some mechanisms of social dispersion, as it happens with other IT developments. This does not necessarily mean that ISs are more dangerous, but it does mean that they are at least more unsettling. And they seem like a step towards a tight automated control of individuals, including permanent biometric monitoring – for instance, banking experts in Latvia predict that this will be implemented within ten years.

> *Otra lieta, kas būs pēc desmit gadiem jeb precīzāk, kas nebūs – nebūs maksājumu kartes kā fizisks objekts. Tās būs izzudušas. Šāda veida objekti kā identifikatori vairs nebūs nepieciešami, jo pats cilvēks var būt pats lielisks identifikators. Pa vidu nav nepieciešams kaut kāds elements, kas apliecina, kas jūs esat.* [18]

After a relatively long period of development in the direction of greater respect for human rights on a global scale, there is now a sense of rollback, both due to the rise of computational technologies, particularly so called artificial intelligence, and some political events, such as the unusually large-scale war in Europe – the Russian invention in Ukraine. We hope that the world will not degenerate to the point where the risks posed by the invasion of information systems are ignored.

For now, it is important for everyone to be socially active in order to minimise the impact of the invasion of ISs. One way to do this is to urge authorities to maintain or establish non-digital alternatives for every service they provide.

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Multiple Path Particle Dosimetry Model Concept and its Application to Determine Respiratory Tract Hazards in the 3D Printing

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Abstract. **The Multiple Path Particle Dosimetry (MPPD) model is computer software that estimates and visualizes the deposition, clearance, and retention of particles in the respiratory tract systems of humans, rats, and other species. The mathematical model provides a broad spectrum of settings and input options. This research aims to explore the MPPD model concept and determine the deposition fraction (DF), clearance, and retained mass in the human respiratory tract (HRT) based on the geometric mean diameter (GMD) and mass concentration (MC) of particulate matter (PM) emitted during the 3D printing process. We used the real-time air sample data collected during the 8-hour working shift in the 3D printing office. Ultrafine PM deposits mainly in lungs (56%), fine PM mostly deposits in the upper respiratory tract (URT) (41%) and lungs (39%), but coarse PM mostly deposits in the URT (81%). The biggest DF in lower respiratory tract is ultrafine PM (487 µg), the smaller DF is coarse PM (185 µg) and the smallest DF is fine PM (123 µg). The biggest DF in lung for all PM - lower lobes (fine PM - 60%, ultrafine PM, coarse PM - 61%). In a model, where exposure was 5 hours a day, five days a week, during one month, followed by one year of post-exposure period, it was shown that retained mass in the tracheobronchial (TB) region was 1% for ultrafine and coarse PM each, 2% for fine PM, and 55% for all PM in the pulmonary region.**
The MPPD software is an easily accessible and valuable tool for assessing the impact of PM on the HRT. Particulate matter decreasing in diameter, tend to deposit mostly in the deeper levels of HRT. Tracheobronchial region clearance is more rapid than pulmonary region clearance.
Potentially for persons using the 3D-printer regularly the worst health impact could be associated with smaller size of PM, due to tendency deposit mostly in pulmonary region where the clearance rate is slower.

Keywords: MPPD model, particulate matter, deposition, clearance.

I. Introduction

In recent years, 3D printing technology has increased rapidly in various industries, such as medicine, military,

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sports, food industries, and spacecraft [1] – [4]. Medicine is no exception – 3D printing is incorporated into the production of patient-specific surgical implants and prosthetics, bio-printed tissues, organ transplants, dental implants and orthodontic aligners, surgical instruments, tools, personalized drug delivery devices [5], [6]. With all the potential developments and trends, the future of 3D printing looks promising and thrilling. We can expect advancements in materials, improved speed, automation of the process, increased use in mass production, customization, personalization, and sustainability [7 – 10].

Nevertheless, using 3D printers has also raised concerns about the potential respiratory health hazards of releasing airborne particles during printing. Multiple studies revealed the increased concentration of different diameter PM and volatile organic compounds in the air samples taken during the printing [11] – [13].

The open - access multiple path particle dosimetry (MPPD v3.04) was used to better understand how 3D printer emissions impact the human respiratory system [14], [15]. It is a mathematical dosimetry model that aids in calculating and visualizing total, regional, lobar, and generation–specific deposition and clearance of particulate matter. MPPD is free of charge and has a user-friendly interface that allows the input of various variables and scenarios. It is successfully used in research, education, and other industries. Since the first time, it was introduced in 1995 by the Hamner Institute for Health Science (USA), the MPPD model has been evolving – applied to the human lung, the rat lung, and particle deposition [16], [17], [18], [19]. The latest model software update included improvements and additions in aerosol distributions, clearance parameters, species geometry models, and visualization of the output files [20]. The dosimetry model is a valuable mathematical tool that can contribute to environmental toxicology research [21].

II. Materials and Methods

Originally, the literature review was conducted to explore the concept of the MPPD model. The MPPD model is one of the most advanced and broadly tested dosimetry models. It considers different aerosol deposition mechanisms such as inertial impaction, gravitational sedimentation, and Brownian diffusion. The input data includes such parameters as airway morphometry, inhalant properties, exposure conditions, deposition, and clearance. In the air morphometry section, the user can choose to model the dose metrics of different species – human, mouse, rhesus, pig and rabbit. Therefore, the model allows intrahuman and interspecies variability. As well as provides multiple choices for the lung models – Yeh/ Schum, Stochastic, Age – specific, Weibel. It is possible to adjust to different scenarios, gender, and age (only for children population, three months – eighteen years) by changing the functional residual capacity (FRC, ml) and upper respiratory tract volume (ml) values. However, there is always a possibility to choose the model's default values. In the next section – inhalant properties, the program provides multiple preferences for the PM characteristics, such as density (g/cm$^{3)}$, diameter (μm), geometric standard deviation (GSD), and mass median aerodynamic diameter (MMAD). Two scenarios - constant and variable exposures - are provided for the exposure conditions by the model. In that section, aerosol concentration (mg/m^3), breathing frequency (x/min), tidal volume (ml), pause, and inspiratory fractions can be modified. Also, it is possible to select preferred orientation and the breathing route – nasal, oral, or combined. MPPD retention and clearance modelling is done in a separate section and contains such parameters as tracheal mucous velocity (mm/min) and lymph node clearance rate (1/days). Additionally, exposure time settings: number of days with exposure to the specific pollutant and number of posts – exposure days. After the calculations, the MPPD output data is presented in textual and graphical form. The model predicts deposition in the entire respiratory tract, as well as based on regions (upper respiratory tract - URT, tracheobronchial - TB, alveolar), lung lobes (RU – right upper, RM – right middle, RL – right lower, LU – left upper, LL – left lower), and by the level of lung generations (from the trachea to the deeper lung tissue - alveoli). The retention, and clearance values are predicted in the tracheobronchial and alveolar regions [14], [16] – [24]. Clearance is the process by which deposited particles are removed from the respiratory tract. Retention - refers to the number of deposited particles present at specific respiratory tract sites that remain after the clearance processes [27].

In this study, the main aspects of the MPPD software were investigated, and three different diameters of particulate matter – ultrafine ($PM_{0.1}$), fine ($PM_{2.5}$), and coarse (PM_{10}) deposition, retention and clearance were modelled in the HRT to explore the possible consequences of working with 3D printers. Real-time air measurement in the 3D printing premises were used during one working shift (8h, including breaks). For the counting of particles was used a low-pressure electrical impactor (ELPI+, Dekati Ltd). All measurements were done at 1.1 meters and as close as possible to the employees' breathing zone. The average value of the geometric mean diameter and mass concentration were calculated for all three groups of PM. We incorporated these two main variables into the model for deposition and clearance. For the PM deposition predictions, all of the available MPPD output was calculated and visualised in the Yeh/Schum lung model. For clearance calculations, the default values were used - for tracheal mucous velocity 5.5 mm/min, clearance rates for the alveolar-interstitial region to the TB region, denoted as slow, medium and fast were 0.0001, 0.001, and 0.02 per day. The lymph nodes clearance rate was 0.00002/per day. Two scenarios were used for the prediction of clearance and retention. The first scenario was 5-hour isolated exposure, the average time 3D office workers would spend in the 3D printing room, followed by a 30-day post-exposure period. The second scenario was

when exposure would be five hours a day, five days a week for one month, followed by a 1-year post-exposure period. The study was approved by the Ethics Committee of Rīga Stradiņš University (Nr. 2-PĒK-4/570/2022).

III. Results

The biggest deposition fraction of PM in the human respiratory tract based on the MPPD model is PM_{10} - 957 µg, the smaller is $PM_{0.1}$ - 569 µg, and the smallest is $PM_{2.5}$ - 209 µg. Furthermore, if we are looking at the particulate matter deposition based on the HRT regions, then $PM_{0.1}$ deposits mainly in the pulmonary region (PU) - 56.2%, $PM_{2.5}$ deposits primarily in the URT - 41.0% and PU region - 39.0 %, but PM_{10} mainly deposits in the URT region - 80.6% (Fig. 1).

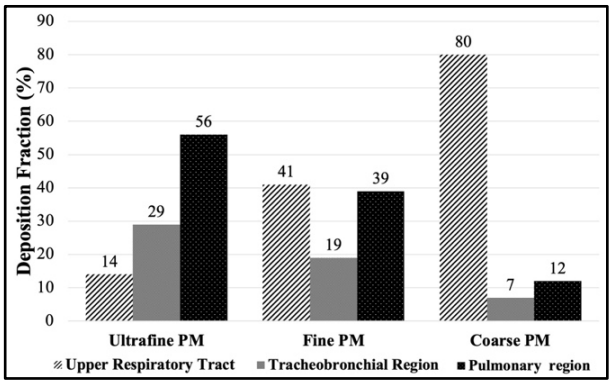

Fig. 1. Ultrafine, fine and coarse PM deposition distribution in HRT.

The biggest deposition fraction in the lower human respiratory tract (LHRT) is $PM_{0.1}$ - 487 µg, the smaller DF is PM_{10} - 185 µg, and the smallest DF is $PM_{2.5}$ - 123 µ (Fig. 2). However, in the URT, the biggest DF is PM_{10} - 771 µg, the smaller DF is $PM_{2.5}$ - 86 µg, and the smaller $PM_{0.1}$ - 82 µg. The biggest DF based on the lung lobe distribution – for all three PM diameters is in the lower lobes: $PM_{0.1}$ - 60.6%, $PM_{2.5}$ - 60.4 %, and PM_{10} - 61.1 %. On the other hand, the smallest DF for all of the PM is in the right middle lobe: $PM_{0.1}$ - 8.0 %, $PM_{2.5}$ - 8.0 %, and PM_{10} - 7.7 %. The peripheral lung region has a higher deposition fraction: $PM_{0.1}$ - 71.3 %, $PM_{2.5}$ - 70.5 %, and PM_{10} - 61.1 %, than the central lung region. For all particulate matter diameters, deposition fraction starts progressing on the level of respiratory bronchioles – 17-19th airway generation and reaches its maximum at the level of alveolar sacs – 23rd airway generation.

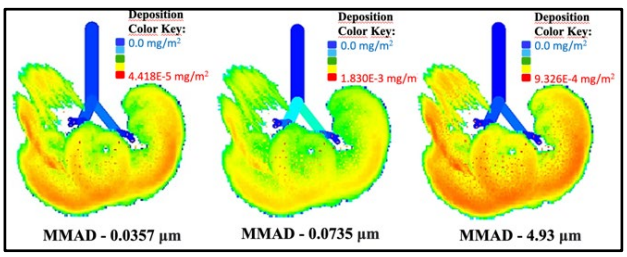

Fig. 2. Deposition Fraction and Mass Deposition rate per area visualization of a – $PM_{0.1}$; b – $PM_{2.5}$; c – PM_{10}. Species and Model Info (Species/Geometry: Human; Breathing route: Nasal; FRC Volume: 3300.0 ml; Head Volume: 50.0 ml. Breathing Parameters (Tidal Volume: 625.0 ml; Breathing Frequency: 12x/min; Inspiratory fraction: 0.5; Pause Fraction: 0. Particle Properties (GSD: 1.0; Aerosol concentration: 0.000025 mg/m^3).

For the clearance of PM, the first scenario was 5-hour isolated exposure, the average time 3D office workers would spend in the 3D printing room, followed by a 30-day post-exposure period. The second scenario is when exposure would be 5 hours a day, five days a week, during one month, followed by one year of post-exposure period.

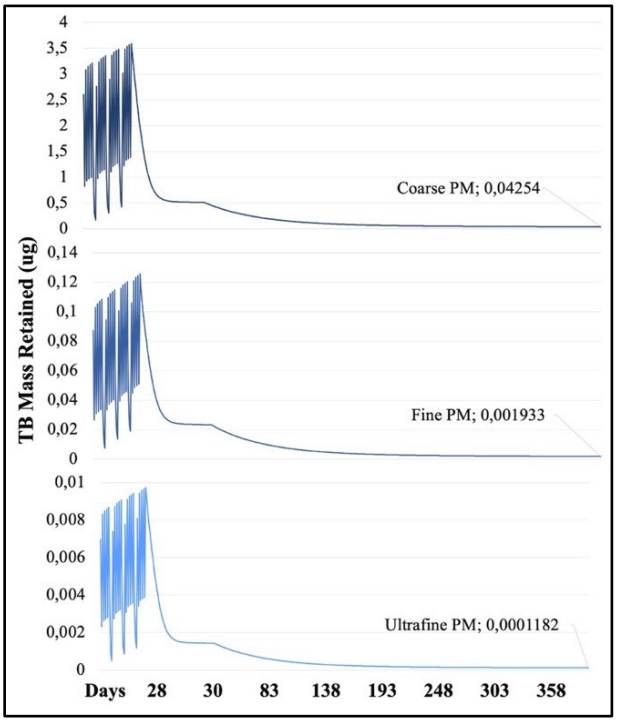

Fig. 3. Ultrafine, fine, and coarse PM retention in the TB region.

In the first scenario, the MPPD model predicted that particulate matter retained mass in the TB region would be: $PM_{0.1}$ - 0.7%, $PM_{2.5}$ - 1.0%, and PM_{10} - 0.8% and in the PU region it would be: $PM_{0.1}$ - 85%, $PM_{2.5}$ - 84.7% and PM_{10} - 84.8%. In the second scenario, the MPPD model predicted that retained mass in the TB region would be $PM_{0.1}$- 1.2%, $PM_{2.5}$ - 1.5%, and PM_{10} - 1.2% (Fig. 3), and in the PU region retained mass would be the same for all three diameters of particulate matter – 54.5% (Fig. 4). The clearance rate of the retained particulate matter for all PM sizes in the TB region was initially high and then decreased. In contrast, the clearance rate in the PU region was consistently low.

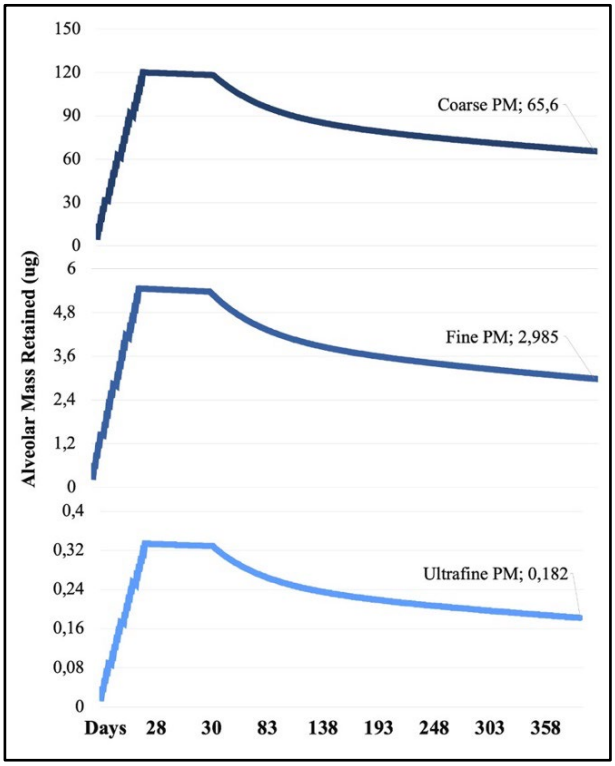

Fig. 4. Ultrafine, fine, and coarse PM retention in the alveolar region.

III. Discussion

The MPPD program is widely used among researchers [16] – [19], [21].

Our results are consistent with previous studies done on this matter. They also suggest similar PM deposition, clearance, and retention patterns in HRT due to 3D printer emissions [20], [23], [26].

Deposition of the inhaled particulate matter can cause inflammation in the different levels and regions of the HRT, especially at the sites with maximum deposit [16]. Multiple studies showed that long – lasting usage of 3D printing could lead to health problems like chronic bronchial asthma (COPD) and bronchial asthma (BA) exacerbation. As well as non – respiratory symptoms such as irritation of eyes and mucus membranes, increased blood pressure, and cardiovascular diseases [23] – [25].

Based on our results, $PM_{0.1}$ has the highest deposition in the pulmonary region. It has a higher probability of reaching the alveoli level of the PU and getting absorbed through the alveolar epithelium, causing systemic inflammation and other organ system and tissue damage. It can also trigger the alveolar macrophages migration, causing the local inflammation [26]. The MPPD model revealed that increased activity level corelates with the increase in the total DF [26].

Study limitations: airway morphometry data entered the program are relevant to the adult person population, so the results cannot be applied to all individuals. It was impossible to include other pertinent parameters in the MPPD model, such as the individual age, medical history, and physical activity. Also, it was challenging to determine the exact amount of time workers spend in a particular with PM polluted 3D printing room during the working day. Still, we predicted that workers spend around 5-hours working in a PM-polluted room.

IV. Conclusions

The MPPD software is an easily accessible, valuable, and widely used tool for assessing the impact of PM on the HRT. It is an excellent addition to inhalation and *in vitro* studies. In some cases, it can be faster and cheaper and give a broader understanding of the deposition, retention, and clearance physiology. It is also a great aid in designing inhalation exposure and human toxicological studies to protect against ambient and occupational biological, chemical, and radiological threats. As well as facilitate dose metrics for the drugs delivered by the inhalation route.

The smaller size of PM tends to deposit in the deeper levels of the human respiratory tract, where the clearance rate is poor. Therefore, people working with 3D – printers for a more extended period and being exposed to the printing emission could have a higher chance of developing chronic inflammation in the respiratory tract and other organ systems or tissue.

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Technological Aspects of Accounting Automation System as a Decision Support System

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Abstract. **Nowadays all businesses need access to an extensive pool of information. Reporting, financial and accounting analysis, financial planning and budgeting are key factors for market-oriented corporate management and successful business. In the digital economy, strong competition, responsible entrepreneurship and corporate social responsibility the business feels a need for revolution and new decision sciences for complex systems that collect big data, analyze it and create reports that can be used by managers for decision-making. The present study aims to prove that the accounting automation system is an important tool for managing the economic activity of companies, because it mediates the interrelationships between managers/decision-makers, or *subjects of management*, economic activity and its results, or *object of management*, in support of Business intelligence, or *BI*, Data and Analysis, Power Platform, etc. The following research tasks have to be settled for reaching the above-mentioned goal: 1. to analyze the components of decision support systems; 2. to research the types of decision support systems; 3. to demonstrate the impact of the accounting automation system as a decision support system on the optimization and improvement of the working processes and making adequate timely management decisions; 4. to analyze the technological aspects of accounting automation system as a decision support system; 5. to research the challenges and solutions regarding ERP systems and SAP. In the course of the study shall be justified the thesis that the successful business is based on true, accurate and reliable information which is mostly generated by automated accounting system as a decision support system and contemporary information technologies. The results of the research are expressed in establishing the way to ensure and guarantee the unification, acceleration and optimization of the *input-processing-output process*, analysis, financial modelling, financial planning, etc. about decision support and respectively wealth management.**

Keywords: accounting automation system, decision support system, information technologies, system structure.

I. INTRODUCTION

Accounting as an information system provides information to various stakeholders to support decision making. In modern economic conditions, the introduction of information technologies will allow the company to increase profits, reduce routine operations, increase employee motivation, which has advantages in the form of cost reduction, lower risks of loss and duplication of information, etc. [1]. These technological transformations also assign to an accounting. Its automation can be a very useful tool for managing the economic activity of companies (enterprises). Making use of Accounting Automation System (AAS) is characterized by a number of advantages. It helps the process to reduce errors in calculations and in accounting records and operations, which will increase the accuracy and timeliness of information in financial statements. AAS also helps in the context of better data management – a process of more efficient storage, management and protection of financial data, which facilitates current and periodic accounting, reporting and analysis. Automation of accounting processes can help businesses to reduce costs regarding to manual data entry, paper-based document processes, and errors correction. By automating accounting activities, companies can free up time for other important activities such as strategic planning, social activities, analysis and making quality management decisions.

All these advantages prove that AAS can successfully be treated as a Decision Support System (DSS) because it supports the automation of the collection, processing and analysis of financial data and its transformation into management information. Specifically, AAS is implemented as a DSS in the following directions:

- Data collection and Data mining. AAS may collect financial data from various sources, such as bank

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statements, invoices and receipts in order to organize, structure and store in a way making it easier to analyze and report [2],

- Financial analysis. The collected and structured financial data from AAS can be used by managers for various analyses such as ratio analysis, trend analysis, and benchmarking, to illustrate the financial position and performance of the company and to support management decision-making [3],
- Reporting. AAS successfully generates financial statements such as balance sheets, income statements, and cash flow statements. These reports can provide a clear picture of a company's financial condition and help stakeholders make informed decisions,
- Strategic decision-making support. AAS allows the generation of forecasts and simulations that managers can use as a basis for scenarios that, after analysis and evaluation, can turn into successful long-term decisions.

In conclusion, an automated accounting system can successfully be associated with a decision support system as it provides timely, accurate and relevant financial information by automating the collection, analysis and reporting of data to serve managers and others stakeholders in the process of preparing operational and strategic management decisions.

II. Materials and Methods

The problems of the implementation of information technologies in business, as well as the current state and the future prospects of management and accounting in modern business conditions and intense challenges, are discussed in a large number of scientific forums and in specialized literature and considered in the works of authors such as J. A. Hall, Joseph W. Wilkinson, Michael J. Cerullo, Vasant Raval and Bernard Wong-On-Wing, G. Tsoncheva, N. Grozeva, F. Filipova, N. Nenov, D. Petrova, A. Deneva and R. Aslanzade, M. Chipriyanov [4] - [12], etc. Of particular importance is the current legislation in Bulgaria – the Accountancy Act, the Bulgarian Electronic Document and Electronic Certification Services Act (EDECSA) on the application of electronic signatures, Regulations, Decrees of the Council of Ministers, National strategy "Digital transformation of Bulgaria for the period 2020-2030", The National Program "Digital Bulgaria 2025", National Recovery and Sustainability Plan from the Council of Ministers of Bulgaria from 2022 [13] - [17], and other.

A research was made by the help of the structured interview methodology amongst non-financial enterprises in Bulgaria, using the method of random sampling without replacement. The sample was formed from small, medium and large enterprises in Bulgaria. The sample does not include micro-enterprises, because the dimension of their economic activity and, accordingly, their volume of work in making managerial decisions, do not impose the need for a Decision Support System (DSS). The methods of Content analysis, induction, deduction, Crosstab and Dynamic SWOT Analysis were also used.

III. Results and Discussion

A. Components of Decision Support Systems

DSS is responsible for the information provision of the decision-making process by providing complex data, analyzing problem situations and preparing possible models. It is an interactive computer-based system and can be research as a composition of different components, as follows:

- User interface. Through this component, the interaction between DSS and all users is achieved. It provides in a convenient way (graphics, text, image) the possibility of entering data, viewing results, visualizing models, adjusting parameters, requests to perform certain activities, generating reports, etc.,
- Data management system. This component is responsible for collecting, organizing and storing data from various sources. It includes tools for data entry, validation, ordering and cleaning, sorting, as well as techniques for data integration and transformation,
- Knowledge base. The database includes information from internal and external sources that is relevant to decision making. Such sources can be records in the accounting system, internal regulatory documents, various legal requirements, press information, information from Internet [18],
- Model management system. This type of system contains multiple models (statistical, mathematical, optimization, simulation, semantic) that managers can use to make management decisions, as well as tools for preparing, testing and validating models [19],
- Communication and collaboration system. It provides managers' and stakeholders' opportunities to connect, share, evaluate, prepare and promote management decisions.

B. Types of Decision Support Systems

The optimal implementation of the goals of DSS is achieved through the information processing of data, the construction of models, the application of specific techniques that support the management process. During the process of its development, the following types of DSS are distinguished depending on the used tools and the role of functional performances [20]-[21]:

- Model-driven DSS: This type of DSS uses mathematical and analytical models to help decision-makers solve problems or make decisions. These models can be simple or complex, and they can include statistical models, optimization models, and simulation models,
- Data-driven DSS: This type of DSS focuses on analyzing large amounts of data to extract meaningful information that can be used to support decision-making. These systems use data mining and machine learning techniques to identify patterns and trends in data,

- Document-driven DSS: This type of DSS is designed to manage and analyze unstructured data, such as text documents, reports, and emails. These systems use natural language processing and text mining techniques to extract information from unstructured data sources,
- Knowledge-driven DSS: This type of DSS is based on expert knowledge and experience. These systems use rule-based reasoning and knowledge management techniques to provide decision-makers with advice and recommendations,
- Web-based DSS: This type of DSS is designed to be accessed over the internet. These systems allow decision-makers to access relevant information and data analysis tools from anywhere, using any device with an internet connection.
- Each type of DSS has advantages and disadvantages. They are decisive in the process of choosing the type of system to be successfully applied in the decision-making process according to the specific needs of managers and other stakeholders.

C. Impact of the Accounting Automation System as a Decision Support System on the management decisions

The progress of information technologies, incl. in accounting, has a significant impact on the optimization and improvement of the working processes and making adequate timely management decisions.

The processing of economic information in ASS is based on the model *input-processing-output*. Users of accounting information are in the role of subjects. At the input of the information system, information provided by users is collected for all registered business processes and operations and economic events.

In the information processing component, the processes of collecting, measuring, storing, analyzing, reporting and managing the information take place as a result of the application of accounting methods and techniques. The results that are generated as outputs are in a state of financial reports, budgets, reports, forecasts and analyses. They are provided to users to support management decision-making [22].

The *input-processing-output* model applicable in AAS is relevant to management because of its multiple advantages, making it a high level DSS. For example, this type of AAS allows the provision of **real-time financial data** to decision makers. This data may include information about business processes and operations related to purchases, sales, revenue, expenses and cash flow. The access to real-time financial data provides options to managers to make decisions based on up-to-date information. A significant advantage is also the possibility of high-quality data analysis - improved data analysis by automating data collection, cleansing, and analysis processes. This helps managers to identify trends and patterns in financial data. They can later be used to optimize processes and improve decision-making. By automating all processes, AAS can also save time and reduce the risk of errors in regard to manual data entry and analysis. Better financial planning via AAS can help managers better plan cash flows. The system provides managers with accurate financial forecasts and planning tools. The tools can help managers to foresee the course of financial needs and respectively to correct and change their strategies. Based on greater clarity about the financial situation, managers make more informed decisions about budgeting, resource allocation and investment opportunities. AAS increases the efficiency of the reporting process, i.e. it **streamlines reporting** by automating the creation and disclosure of financial statements. This helps managers to save time and reduce the risk of errors in regard to manual reporting. In addition, it ensures that all stakeholders have access to accurate and up-to-date financial information. AAS as DSS can be systematized in several types: Management Information Systems, Financial Decision Support Systems, Budgeting and Planning Systems, Performance Management Systems, Enterprise Resource Planning (ERP) Systems. All of them serve certain activities in the management process – planning, organization, reporting, analysis, control. This shows the effective collaboration between accounting, information technology and management. AAS as a DSS provides managers with timely and accurate information to support better decision making, improving the performance and financial results.

D. Technological aspects of the Accounting Automation System as a Decision Support System

AAS as DSS uses various technologies to automate and streamline accounting processes. The quality processing of incoming accounting information is a key factor for the success of organization, because it is the basis for making management decisions. The role of the AAS is to ***data capture and processing***. AAS collects large amounts of data from various sources quickly and accurately. This data can be captured electronically and automatically imported into the system, reducing the need for manual data entry. AAS processes them quickly and accurately, and specifically classifies business processes and operations/categorizes transactions, makes relevant entries in accounts on an ongoing basis, periodically summarizes the information in accounting registers and generates financial statements. In addition, AAS successfully integrates with other management information systems, such as CRM, payroll management systems, inventory management systems, that exchange and process data each other in real time.

Artificial Intelligence and Machine Learning are modern technological solutions that can be successfully integrated within AAS as DSS. They have wide applications in various directions. For example, AI-powered systems can perform automated data entry, expense categorization and financial statement preparation. These activities include extract data from different resources and financial documents and automatically input it into accounting systems, automatically categorize expenses based on factors such as suppliers, category, and amount and then generate financial statements such as balance sheets and income statements automatically. This

save time, reduce errors associated with manual data entry, and help streamline the expense reporting process.

Machine learning algorithms can analyze large amounts of financial data to identify patterns that may indicate fraud activity (fraud detection) more quickly and accurately. Also they can analyze historical financial data to predict future cash flow and help businesses manage their cash flow more effectively.

Artificial Intelligence and Machine Learning together can be used to analyze financial data and make predictions about future trends and outcomes. This can help businesses plan more effectively.

Cloud computing provides numerous advantages to AAS. They can successfully provide users with remote access to accounting information from anywhere in the world through an Internet connection. The accounting process within cloud technologies also allows automation of repetitive tasks and real-time financial reporting and analysis. This means that accountants can work from anywhere, which can save time, increase productivity, reduce errors. An advantage of Cloud-based accounting systems is an opportunity for integration with other software and management systems such as Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM). Users, channels, storage and features can also be easily added or removed. Thereby AAS as DSS provide a comprehensive view of an organization's financial and operational performance. This definitely increases the quality of management decisions [23].

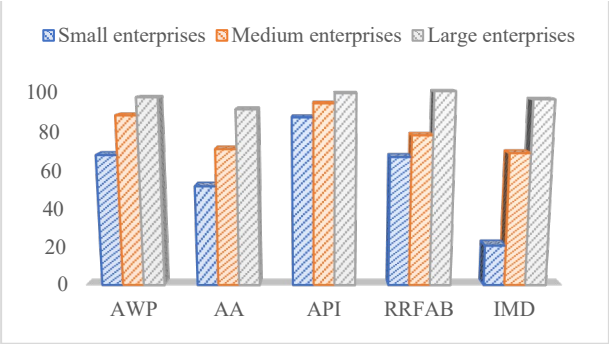

Fig. 1. Level of knowledge of the functional capabilities of the ERP according to the categories of businesses in percentage.

AAS uses ***analytics and reporting tools*** to generate financial reports, dashboards and other visualizations. These tools allow users to analyze financial data and identify trends, risks and opportunities to support management decision making.

E. ERP systems and SAP in practice

A research was carried out, which aims to establish to what extent enterprises are familiar with the functional possibilities of ERP: automates all work process (AWP), accelerates the activities (AA), accumulates and processes information (API), rapid reporting, planning, forecasting, analysing and budgeting (RPFAB), integration with mobile devices powered by Windows Mobile and Android (IMD).

The sample was formed from small, medium and large enterprises in Bulgaria by the method of random non-recurrent selection. The sample does not include micro-enterprises, because the dimension of their economic activity and, accordingly, their volume of work in making managerial decisions, do not impose the need for a Decision Support System (DSS) such as the ERP system. Period of the survey March 2018-March 2023. The results have found expression in (Fig. 1).

100% of respondents believe that ERP is an analogue of maximum automatization of the working processes and provides fast, secure and reliable information in real time for making decisions. More than 70 % of them consider that this is a successful way to add business value. The largest percentage of respondents associate ERP with the fact that it accumulates and processes information. The lowest percentage observed in small and medium-sized enterprises refers to integration with mobile devices powered by Windows Mobile and Android. At the same time, this is mainly within the power of large enterprises.

Based on our research, we propose the following model of DSS (Fig. 2).

Our next step was to determine whether the different types of enterprises of the sample have the financial resources and competent personnel to work with ERP.

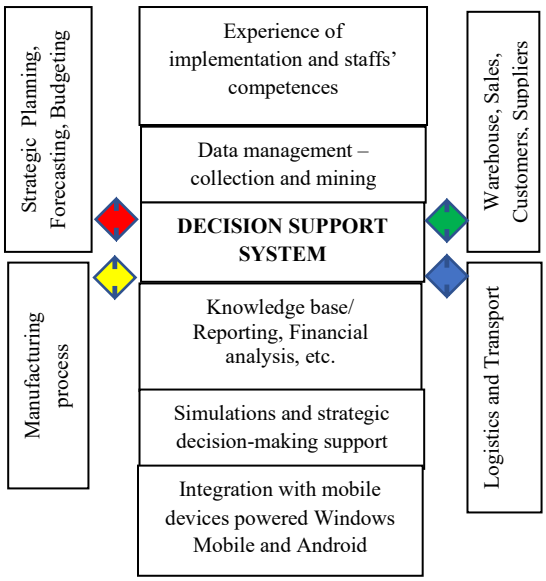

Fig. 2. Model of Decision Support System (DSS).

The results (authors' own research) have found expression in Table 1 by Crosstab. 55,84 % of the sample answered *yes, definitely*. Nearly 27 % of all respondents answered *more than likely* and almost 17 % of them answered we *will analyze further*.

Respondents of the sample define as the most popular ERP systems: SAP, Zeron ERP Business software and Microsoft Dynamics NAV.

Regarding SAP our research shows that SAP is a leader in ERP for the business sector. This software for managing the business processes is sold as Windows – worldwide.

Decision-making software such as Zeron ERP Business Software and Microsoft Dynamics NAV, for example, are sold in Bulgaria and are developed and adapted in accordance with Bulgarian accounting and tax legislation.

TABLE 1 FINANCIAL RESOURCES AND HUMAN CAPACITY

			Categories of businesses (Accountancy Act, amm. SG/ 26 dated 22 March)		
			Small enterprises	Medium enterprises	Large enterprises
Are you ready to adapt your business model…	definitely yes	Count	17	12	14
		% within categories	43,59%	57,14%	82,35%
	more than likely	Count	13	6	2
		% within categories	33,33%	28,57%	11,77%
	we will analyze further	Count	9	3	1
		% within categories	23,08%	14,29%	5,88%
Total		Count	39	21	17
		% within categories	100,0%	100,0%	100,0%

TABLE 2 DYNAMIC SWOT ANALYSIS

External Factors	
OPPORTUNITIES	THREATS
▪ ability to successfully develop market Segments.	▪ counteraction to the risk of entry of new competitors.
Internal Factors	
STRENGTHS	WEAKNESSES
√ increasing the flexibility of the price policy; √ facilitated development of strategies for entering new markets; √ increasing the efficiency of the logistics system; √ increasing customer and consumer satisfaction.	√ increased management costs; √ potential difficulties in the phased integration of all modules of the system √ need for constant improvement of staffs' Business Intelligence (BI) competences (regular trainings).

It was a challenge for us to do a SWOT analysis as well. We use a dynamic SWOT analysis (Table 2) as a technique for assessing the aspects of using ERP in the business as follows: in the past, currently and in the future.

The opportunities, threats, strengths and weaknesses resulting from the implementation of business intelligence solutions are analyzed.

By implementing the ERP in the enterprise, the external environment cannot be influenced. The use of the software for the management of business processes and developing solutions cannot analyze market conditions and cannot influence consumer demand or tax legislation.

It uses information one and only from the warehouse, manufacturing process, sales, etc. as well as all internal processes to support management.

For example, disrupted supplies as a result of the Covid-19 crisis and the war in Ukraine will be treated as an external threat, as for all enterprises and businesses.

IV. CONCLUSION

Under the conditions of a market economy, one of the most important resources is the information, and the computerization of enterprise management in the context of planning, forecasting, decision-making and control is an important competitive factor. Therefore, it is extremely important for every enterprise to create and develop a system that supplies it with true, reliable, accurate and timely information, so-called Decision-support system (DSS).

First. DSS can be researched as a complex system of components and subsystems that are characterized by continuous connection and exchange of data in the relationship *input-output*. The outgoing information possesses the qualities of elasticity, quality and usefulness and is intended to increase the managerial productivity of the management.

Second. In order to achieve speed and accuracy in the process of processing a large amount of data with high quality of output information, minimizing errors and convenience in using information in time and space, DSS should be computer-based, automated and with an option to work across different mobile devices.

Third. The AAS, as a system that provides a comprehensive and reliable coverage of all business operations and processes in the enterprise – performs a major informative and controlling role in the reporting process. It can reasonably be analyzed as a decision support system with basic principle characteristics: objectivity, connectivity, integrity, stability, adaptability, productivity, effectivity.

Fourth. AAS as DSS can provide advanced analytics tools, such as predictive modelling and data visualization, that can help identify trends, patterns, and insights that may not be immediately apparent from traditional financial reporting. This can help managers to make more informed decisions based on deeper insights into financial and operational performance.

Fifth. DSS can improve communication and collaboration among employees, departments, and stakeholders by providing a centralized platform for sharing and accessing financial and accounting data. This can help

reduce the risk of miscommunication, duplication of effort, and data inconsistencies.

Sixth. Nowadays, in the conditions of digitization, transformation and automation of all business processes, it should be noted that ERP system can successfully be analyzed as a high level DSS in the companies. Its core is the main and most important module – the accounting module, through which varied information in a direct and feedback relationship flows with all other modules.

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Accumulated Laboratory Data in B12 Vitamin Blood Level Time Dependency Studies in Patients with Myeloma, Lymphocytic Leukemia and Myeloblastic Leukemia in Latvia

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Abstract. **Vitamin B12 blood level in patients with myeloma (C90 - International Classification of Diseases (ICD-10)), lymphocytic leukemia (C91) and myeloblastic leukemia (C92) prior and after the diagnosis and also BCR-ABL (fusion gene from *breakpoint cluster region BCR* gene and *tyrosine-protein kinase ABL1* (Abelson murine leukemia) gene) tests for C92 patients were studied.**

Clinical records of 20 C92 patients in Riga East University Hospital were complemented with 6987 B12 clinical test data accumulated in E Gulbis laboratory (EGL) for 7451 patients over 20 years period. BCR-ABL and B12 dynamics for 11 patients with sufficient number of BCRABL and B12 tests were studied.

Oracle Cloud with pseudonymized data replica from more than 350 000 000 original EGL clinical test data was used. The data were selected by online analytical processing and SQL built in tools and then used in offline analysis and visualization.

Annually there are 107, 189 and 91 confirmed cases of C90, C91 and C92 in Latvia. EGL has 30% more C90-92 patients, due to suspected but later unconfirmed cases. Out of 7451 patients 1386 had one B12 test, two- 548, three and more- 864. The patients with diagnosis fluctuating between C90, C91 and C92 were excluded from the study. The data for the time period of 10 years before and after the first diagnosis were analyzed.

Results. Methods and tools for data extraction and analysis from large amount of archived clinical test data were developed and applied. High and very high B12 level was observed for 53% of C92 patients starting from 3 years prior to diagnosis. For C90 and C91 patients B12 level changes around the diagnosis date were also observed although the effect was considerably smaller. Analysis of 11 selected patient data with clinical records showed timewise correlation between B12 and BCR-ABL for 3 of the patients.

Keywords: B12 vitamin, myeloma, lymphocytic leukemia, myeloblastic leukemia, laboratory data.

I. Introduction

Medical research usually is time consuming and often involves relatively small groups of persons to be studied. Apart from case studies and larger epidemiologic studies typical research has few dozens and up to few hundred persons studied and involves extensive field work to select and recruit the patients. Advancement of IT technology together with the development of large clinical laboratories has a potential to change the part of the medical science that works in harmony with the results of clinical analysis. Use of IT allows to scan through large amount of accumulated patient data, screen and select the

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data relevant for the chosen research topic. As a result it speeds up medical research and enables better understanding of the connection between different medical conditions and the laboratory test results and reduces the time and resources needed to generate new knowledge. Description of mathematical methods used for extraction of reference intervals from accumulated data are in [1].

In this work a technology designed to extract and analyze anonymized data from large clinical laboratory test result database that is representative of the whole population of Latvia was used. The technology has been developed in Egils Gulbis Laboratory (EGL), Riga, Latvia. There are several challenges in working with accumulated data like data protection, potential data leaks, patient selection for analysis and speed of data processing.

Study of B12 vitamin in Latvia population was selected as the test playground for this technology.

In this work a large amount of clinical test data accumulated in EGL over the period of more than 20 years was analyzed. Study includes results of the vitamin B12 blood level over time period of 10 years prior and after the first diagnosis for patients with myeloma (C90 - International Classification of Diseases (ICD-10)), lymphocytic leukemia (C91) and myeloblastic leukemia (C92). The results of this in silico study were complemented with a limited study of clinical records of 20 patients selected from the cohort of 60 patients from Riga East University Hospital. The clinical record study also includes analysis of BCR-ABL fusion transcript results for C92 diagnosed patients.

The diagnosis group C92 is subdivided in following groups: C92.0 (acute myeloblastic leukemia), C92.1 (chronic myeloblastic leukemia), C92.2, C92.3, C92.4, C92.5, C92.6, C92.7, C92.8, C92.9 [2]. Publicly available statistics in Latvia distinguishes only C92.0 and C92.1 subgroups of C92 diagnosis [3]. All other data are not differentiated under C92 group of diagnosis. In this work the diagnoses C90, C91, C92 were used since subgroups are not always defined for laboratory patients.

The 92.1 diagnosis is usually confirmed by combination of karyotyping and / or FISH and complete blood count. In the case of positive BCR-ABL fusion transcript, specific tyrosine kinase inhibitors are prescribed for treatment. Therapy efficiency and disease progression are then monitored with BCR-ABL Real-Time Quantitative Polymerase Chain Reaction (RT-Q-PCR or PCR) test [4], [5].

In less than 10% of patients with chronic myeloblastic leukemia (CML), the Philadelphia chromosome (Ph) is not identified, but there is presence of the associated BCR-ABL molecular abnormality (Ph-negative, BCR-ABL-positive CML) detectable by PCR [4], [6], [7]. Up to 5% of all CML patients are BCR-ABL negative [8]. BCR-ABL negative and BCR-ABL-positive CML patients differ by clinical manifestations such as age, leucocyte count, monocyte count, basophil count, percentage of blasts in peripheral blood, response to chemotherapy and survival [7], [9], [10]. Ph-negative, BCR-ABL-positive CML patients usually have no other chromosomal abnormalities prior to diagnosis, but approximately 30 % BCR-ABL-negative CML patients have an abnormal karyotype at the time of diagnosis [8], [9].

Since B12 is not synthesized by human tissues the blood level depends on the dietary and intentional intake of the vitamin. The dependency of the B12 level on lifestyle, dietary patterns and B12 intake should be taken into account when interpreting B12 data. Elevation of B12 blood level can be divided into elevated and significantly elevated. Significantly elevated B12 level is defined in this study as more than 2.5 times higher than of reference interval (RI). There are different medical conditions related to these two groups of elevated B12 levels. Moderate elevation of B12 among other causes can be related to kidney and liver damage that can also be a side effect of oncological treatments.

There is a number of reports that links significantly elevated B12 level with some medical conditions for example chronic myeloid leukemia [12],[13], [14], [15], hepatocellular carcinoma [14], [16], [17], polycythemia vera [15], [16], chronic myelomonocytic leukemia [16], primary hypereosinophilic syndrome [7], [15], promyelocytic leukemia [16], myelodysplastic syndrome [16], primary myelofibrosis[16], acute leukemia [16], liver metastases [16], breast cancer [16], colon cancer [16], cancer of the stomach [16], pancreatic tumours [16], liver disease [15], [16], [17], [18], kidney disease [14], [15], [16], [18], autoimmune diseases [14], [15], [16], bronchopulmonary disease [15], [16], alcoholism [14], [15], [16].

For myeloblastic leukemia elevation of B12 is caused of proliferation of myeloid cells containing B12 bound to transcobalamin I.

It has been reported that B12 can be an earlier marker for some oncological diseases [11]Click or tap here to enter text..

II. EXPERIMENTAL TECHNIQUE

A. EGL clinical test result database

EGL database stores clinical test results for all patients tested in laboratory together with patient basic data like age, sex, affiliation with medical establishment, diagnosis provided by physician for each of the test requests, source of the test request for each of the tests. There are more than 100 000 000 results of clinical test data in the database. Size of Latvia population is 2 million. As EGL serves the whole of Latvia the database is representative for the whole of the population of Latvia. Original patient data are stored in EGL information system based on Intersystems Cache. Full data replication to Oracle Cloud was used for faster and simpler processing. Ability to use Oracle analytic window functions and row pattern recognition allows for more accurate and expressive data selection criteria than basic standard SQL. Replication was built using Oracle APEX REST data service with structure-independent JSON data records, further mapped to native

tables as materialized views for increased performance. Patient identity was replaced by patient number, all analysis referring a particular patient number can be retrieved from the data replica. For work with several data sources like different laboratories or medical record banks an additional tool for data transfer including patient identity and adding data source identity into the aggregated data set would be needed. The data needed for specific tasks were selected by online analytical processing and SQL built in tools and used in offline analysis and visualization.

The data used in this work were from EGL IT system. In the analysis small subset of data was complemented with data from patients' clinical records from hospital.

Several laboratory methods were used over the time for the B12 tests. Prior to data matching the uniformity of the results were tested and no correction coefficients were needed to match the results from different methods. There was only one apparatus performing B12 tests at any given time, so there was no need to use the identity of the apparatus in the data analysis as this information was in unique way related to the time of the B12 test. Batch data for the chemical reagents were not used in this work although the system use the batch data as well.

Adoption of the system to process different data sources with numerical values would require specific data transformation code for each data source to bring the data into unified format and the data processing tool that transforms the data obtained with different methods and apparatus into unified value system for each type of measurement, For B12 vitamin the standard sample test results can differ up to 20% and even more between different laboratories, within the framework of international quality control the coefficient of variance between different laboratories is 15% [19].

Several subsets of data were used for the purpose of this work. One subset was 7451 patients with C90, C91 and C92 diagnosis. Another subset was data of B12 blood level measurements from 132379 patients.

The complete data replica in the Oracle was used to compactify the selected data sets and create data arrays suitable for later analysis in Excel or in any other program the research team members might prefer to work with.

B. Laborathory methods

All analysis was performed in E. Gulbis Laboratory (EGL) – a certified (ISO/IEC 17025, ISO 15189:2013) clinical laboratory (Riga, Latvia), which provides laboratory services in all regions of Latvia. All the testing was performed according to the reagent manufacturers' user manuals.

B12 tests. Electrochemiluminiscence immune - assay's (ECLIA) method [T1] performed on the Cobas e 801 analyzer was used in EGL from December 2017 up to current time. Manufacturer's RI for this method is 197-771 pg/ml. From March of 2012 till December of 2017 the method based on ECLIA [T2]. Manufacturer's RI for this method is 191-663 pg/ml. From January of 2004 till March of 2012 tests were performed on Elecsys 2010 analyzer. Manufacturer's RI for this method is 180-900 pg/ml.

As the part of regular laboratory procedure, the accuracy of B12 tests was regularly checked against standardized samples and the coefficient of variation (CV) defined as the standard deviation (SD) divided by the mean and multiplied by 100 was calculated. For most of the time CV was below 4%.

BCR-ABL tests. EGL uses The Xpert BCR-ABL Ultra to perform BCR-ABL monitoring tests.

The Xpert BCR-ABL Ultra, performed on the Cepheid GeneXpert Instrument Systems, is an in vitro diagnostic test for the quantitative detection of the BCR-ABL1 chromosomal translocation mRNA transcripts (types e13a2/b2a2 or e14a2/b3a2) and the ABL1 endogenous control mRNA transcript in the peripheral blood specimens from patients previously diagnosed with chronic myelogenous leukemia (C92, CML) [10]. Method is automated, quantitative, real-time, reverse transcription polymerase chain reaction (RT-RT-Q-PCR or PCR).

For a positive result the software calculates the % BCR-ABL/ABL (IS) using the equation

%BCR-ABL/ABL IS = EΔCt(ΔCt) x 100 x Scaling Factor (SF) where delta Ct value is obtained from ABL Ct minus BCR-ABL Ct.

For a negative result the software calculates a theoretical BCR-ABL/ABL ratio by subtracting 32 from the test ABL Ct (Test ABL Ct-32) using the same equation. And the given result is BCR-ABL was not detected at a detection limit of %(IS).

The scaling factor (SF) is a lot-specific parameter that is embedded within the test cartridge barcode. The value of this factor and the lot-specific EΔCt are determined in quality control testing of each assay lot using secondary standards derived from the world Health Organization (WHO) international genetic reference panel for quantitation of BCR-ABL transcript. Together, the secondary standards and the lot-specific EΔCt and SF values, calibrate the quantitative output the assay to the IS. The SF value is arbitrarily set for 1.22 for use in the example shown here.

C. Patients

Annually there are 107, 189 and 91 confirmed cases of C90, C91 and C92 in Latvia according to the statistics [3]. EGL data has 30% more patients with C90-92 diagnosis than Latvia statistics, the difference can be attributed to suspected but later unconfirmed cases. No selection was done against these cases. BCR-ABL test results indicate confirmed diagnosis. Out of 7451 EGL patients with C90-C92 diagnosis 1386 had one B12 test, two- 548, three and more- 864. The patients with diagnoses fluctuating between C90, C91 and C92 were excluded from the study (unspecified or unconfirmed specific oncohematologic diagnosis). The data for the time period of 10 years before and after the first diagnosis were analyzed. Out of 60 preselected clinical records of C92 patients in Riga East

University Hospital 20 patients with less "side diseases" and less complicated clinical history were selected for this study. Very few B12 data were found in the clinical records of the hospital while considerably more B12 data were accumulated in EGL database for the same patients, the reason being that patient clinical record at hospital has only the results of the tests done during hospitalization or treatment. The study was approved by Riga Stradins University and Riga East University Hospital ethics boards.

III. Results and Analysis

The number of B12 tests performed by persons with diagnosis C90-C92 is given in fig. 1. There are few tests done earlier than 2 years before the diagnosis. 1 year before the diagnosis the number of tests more than triples and after the diagnosis the frequency of testing increases twenty times. The first statistically reasonable sign of moderate elevation of B12 blood level is observed 1 year before the diagnosis for C90 and C92 and only after the diagnosis for C91.

Patient B12 values were divided into 5 groups – "normal" – within reference interval (RI) 197-771 pg/ml where 95% of healthy individuals are within RI; reduced (100-197 pg/ml) and significantly reduced (<100 pg/ml); elevated (771-1700 pg/ml) and significantly elevated (>1700 pg/ml). Out of all 412966 B12 tests performed by EGL 9,3% had

elevated and 1,3% had significantly elevated B12 level. Since there were very few patients with sufficient number of B12 tests we could not get representative results for the time variation of B12 from the analysis of few individual patients. To get an averaged time dependency of B12 level from the diagnosis date we used an approach where all patient B12 values were analyzed against the time of first C diagnosis. B12 blood level development over the time for the patients can be established by following individual patients and performing many B12 tests at regular time intervals. This approach might work only after the patients' diagnosis is confirmed but not before that date. In our work we assume that large number of patients with few B12 test results distributed randomly over the time can provide averaged tome dependency of

B12 level. Using many patients with few B12 tests for each of the patients would better represent the potential deviations from the main trend that might be missed using only few patients with frequent test results.

For the patients studied the number of B12 tests that falls into each of the intervals were counted for 5 time intervals before the diagnosis and 6 time intervals after the diagnosis in total covering 10 years before and 10 years after the diagnosis. The lengths of the time intervals were adjusted to collect sufficient number of results within each of the intervals.

For elevated B12 values for patients with C91 diagnosis the number of tests within the elevated B12 value corridor did not deviate from 9,3% of the number tests performed. Only for patients with C90 and only at interval 1 to 2 years year after the diagnosis date and for patients with C92 from -1 year to 2 years with respect to the diagnosis date the number of tests exceeded the expected average number by at least 3 standard deviations.

For significantly elevated B12 values, (>1700 pg/ml) shown in fig. 2, the number of tests exceeded the expected number of tests by more than 3 standard deviations in the time intervals -1 to 0 years and 1 to 2 years with respect to the diagnosis date for C90; 3 to 8 years after the diagnosis date for C91 and from -2 years to 5 years for C92.

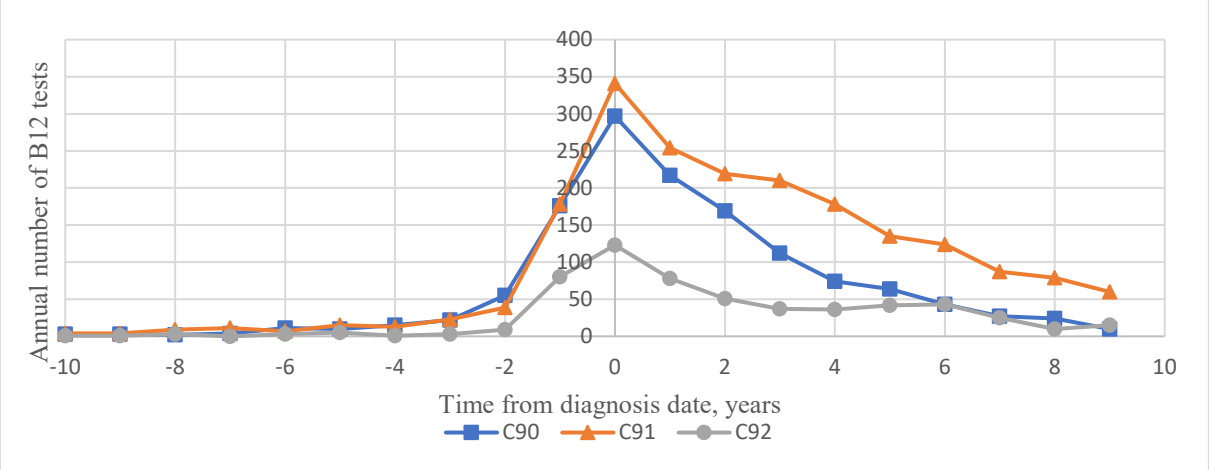

Fig. 1. A2 Annual number of B12 tests performed at EGL for patients with myeloma (C90) -blue squares, lymphocytic leukemia (C91) - orange triangles and myeloblastic leukemia (C92) – grey circles diagnosis prior and after the diagnosis date. . The intensity of testing B12 starts sharp increase 2 years before the diagnosis.

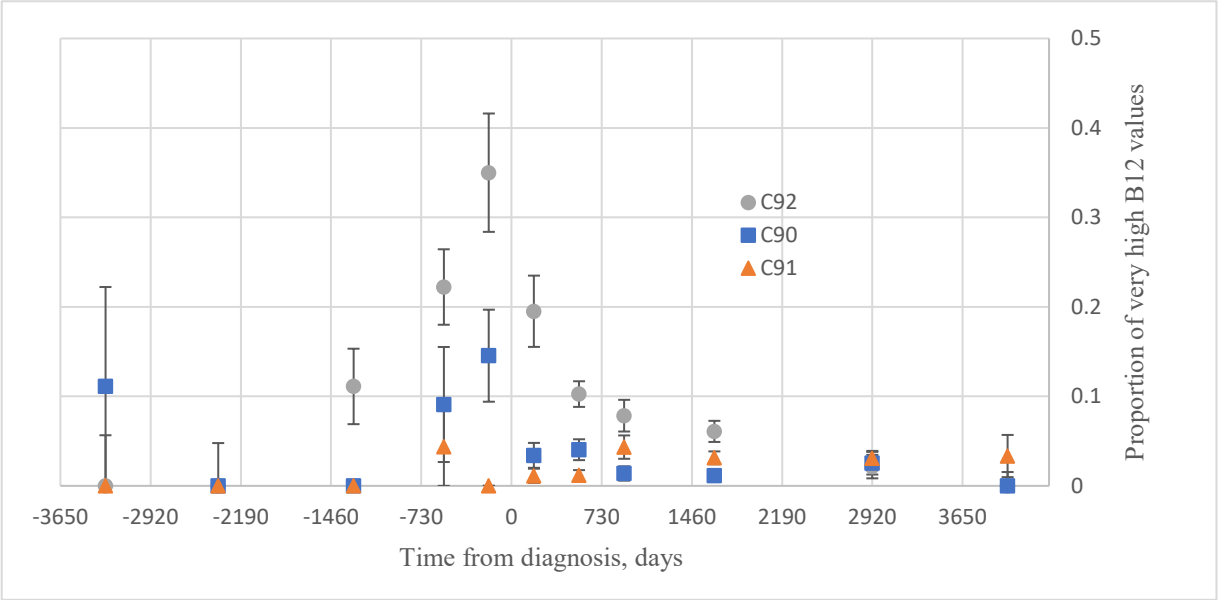

Fig.2. A3, Proportion of significantly elevated B12 test results (>1700 pg/ml) for patients with myeloma (C90) - blue squares, lymphocytic leukemia (C91) - orange triangles and myeloblastic leukemia (C92) – grey circles, in time intervals with respect to the diagnosis date.

These results can be interpreted that for some diagnosis in C92 group it is known that B12 is released in blood and very high B12 indicates that part of the patients have had the disease several years before the diagnosis. For C91 it seems that after remission period a new type of leukemia associated with very high B12 values develops for 3-5% of the patients. Results for C90 are more difficult to interpret.

BCR ABL and B12 dynamics for 11 C92 patients with sufficient number of BCR ABL and B12 tests was studied. Clinical records from the hospital had very few B12 data since only the tests performed while in hospital were kept in the records. The clinical record data were supplemented with the B12 and BCR-ABL data from EGL database. The patients have possibility to perform the tests at other laboratories as well and we do not have access to integrated datasets for the patients. Thus, the clinical test data might be incomplete.

In 3 cases patients had significantly elevated B12 and positive BCR-ABL around the diagnosis time and then both B12 and BCR ABL lowers to normal values in fig.3. This we interpret as the sign of successful therapy.

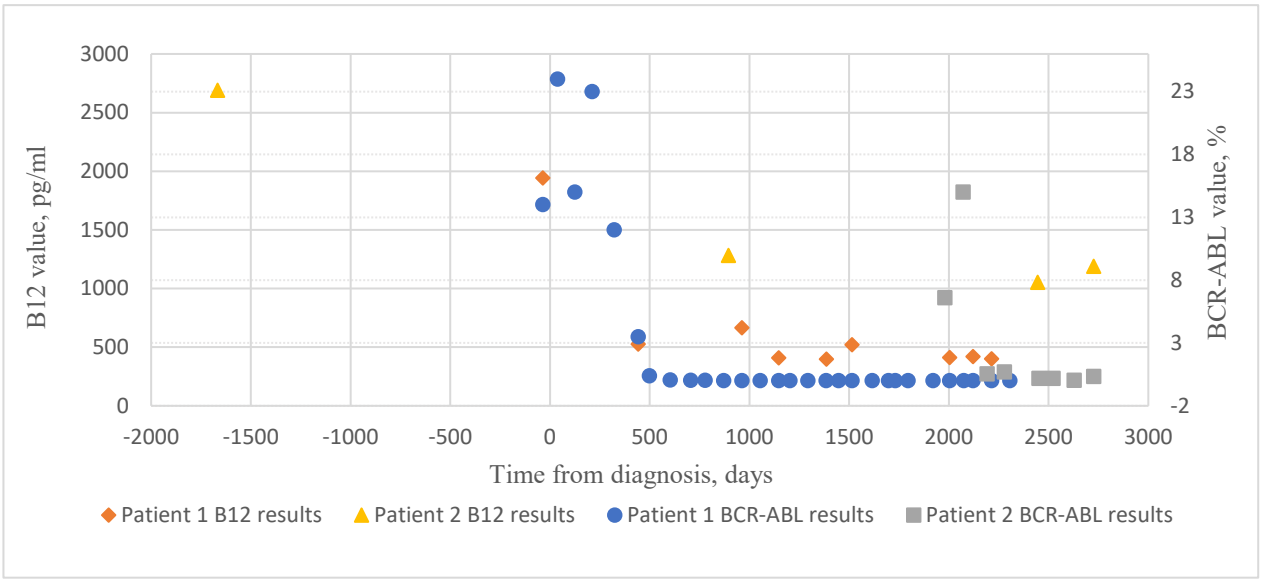

Fig.3. A typical time development of B12 and BCR-ABL test results with respect to diagnosis date. Patient 1 have responded to therapy within 500 days. B12 have returned to reference interval and BCR-ABL is negative. For patient 2 after 5 years BCR-ABL turns to negative, but all B12 tests are significantly elevated

In one case an initial significantly elevated B12 level returned to reference interval value after some time while BCR ABL fusion transcript level was not reduced and B12 again rises to elevated level after 5 years. One patient had significantly elevated B12 that lowered to elevated B12 after 5 years but all 26 BCR ABL tests were negative.

There was timewise lowering of B12 values but no visible timewise correlation between B12 and BCR ABL for 4 of these 11 patients.

Rest of the patients (2) had not sufficient number of BCR ABL data for detailed analysis.

IV. Summary

Methods and tools for data extraction and analysis from large amount of archived clinical test data were developed and applied. With this method the B12 values with respect for the diagnosis data for myeloma (C90), lymphocytic leukemia (C91) - and myeloblastic leukemia (C92) patients were studied. Up to 40% of C92 patients showed significantly elevated B12 in time window -2 to 2 years with respect to the diagnosis date.

B12 tests looking for significantly elevated B12 levels (>1700 pg/ml) can be used as an additional tool to monitor the recovery of patients with C92 diagnosis and can identify suspected cases where BCR ABL tests have become negative after the treatment. Unexpected rise of B12 to significantly elevated values after the successful treatment can be a signal to look for some other diagnosis similar to the one that was cured.

Further developments on the availability of medical records for computerized data analysis together with laboratory test data would open new possibilities in creating new knowledge in interpretation and use of the clinical test data.

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Simulated Annealing Method in the Classic Boltzmann Machines

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Abstract. **The classical Boltzmann machine is understood as a neural network proposed by Hinton and his colleagues in 1985. They added noise interferences to the Hopfield model and called this network a Boltzmann machine drawing an analogy between its behaviour and physical systems with the presence of interferences. This study explains the definition of "simulated annealing" and "thermal equilibrium" using the example of a partial network. A technique for calculating the probabilities of transition states at different temperatures using Markov chains is described, an example of the application of the SA - travelling salesman problem is given. Boltzmann machine is used for pattern recognition and in classification problems. As a disadvantage, a slow learning algorithm is mentioned, but it makes it possible to get out of local minima. The main purpose of this article is to show the capabilities of the simulated annealing algorithm in solving practical tasks.**

Keywords: Boltzmann machine, simulated annealing, thermal equilibrium, travelling salesman problem.

I. Introduction and Theoretical Background

Two articles by Hopfield [1],[2] were essential to the notion of the connection between brain processes and physical systems.

The disadvantage of Hopfield networks is their tendency to stabilize at local but not global energy function minima. This shortage is largely overcome by a class of artificial neural networks (ANN) known as the Boltzmann machine (BM). The classic BM machine is a neural network proposed by G. Hinton and his colleagues in 1985 and described in the study [3]. In the BM changes in neuronal states are given by statistical, but not deterministic, relationships. There is a strong analogy between these methods and the process of cooling metal, so the methods themselves are often referred to as "simulated annealing" (SA).

One possible type of BM machine architecture is shown in Fig. 1.

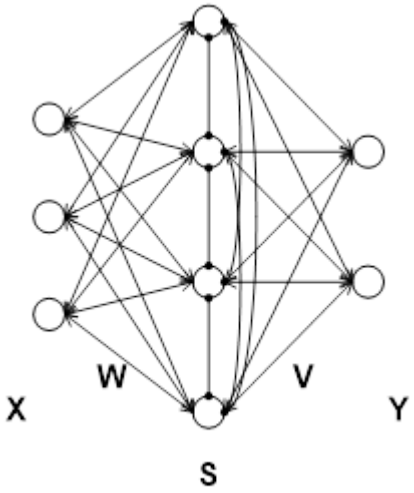

Fig. 1. An example of Boltzmann machine.

The elements of a BM are divided into two functional groups - a non-empty set of visible elements (neurons) and a (possibly empty) set of hidden elements. Visible elements (X and Y in Fig. 1) - the interface between the network and the external environment. During the training, the visible elements will be strengthened in specific positions, which are determined by the needs of the task to be solved, namely, any set of visible elements can be strengthened. The hidden elements (S in Fig. 1), if any, are never strengthened and are used to help describe the links in a set

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of input vectors, which cannot be assigned directly as the relationship between the visible elements.

The BM training procedure has 4 steps:

(1) The "artificial temperature" T is given a high initial value.

(2) The input vectors are passed through the network, then the output values and the target function are calculated.

(3) The weight values are changed, then network output values and the target function are recalculated.

(4) If the value of the objective function is decreased (improved), the change in weight is retained.

If the change in weight leads to an increase in the objective function, then the probability of maintaining this change is calculated using the Boltzmann distribution:

$$p(c) = e^{-c/kT} \quad (1)$$

where p - probability of target function change, k - constant (analogous to Boltzmann constant), T – "artificial temperature".

The concept of "artificial temperature" is related to the already mentioned SA. It is a stochastic optimization method used to optimize the objective function (energy).

The SA method allows to find a global extremum for a function that has local minima. The principle of SA was announced in classical study [4] and developed in studies [5]-[10]. Nowadays, the SA method is considered to be an independent field of research and is separated from the ANN methods. SA is based on an analogy with statistical mechanics, specifically with solid-state physics elements. A practical example from metallurgy is what happens to the atomic structure of the body by rapidly cooling it, lowering its temperature. A sharp drop in temperature can lead to an asymmetrical structure of the system or, in other words, to a suboptimal state (with errors). Cooling eventually causes the system to freeze and thermal equilibrium is reached.

The so-called Metropolis procedure [4] determines the iterative steps that control the achievement of the best solution. This algorithm is used to simulate equilibrium for a given temperature. In each step of this algorithm, the atom is given a small probable displacement - $x_i + \mathrm{y}$ and the system energy change E is calculated.

If $E < 0$, then the displacement is accepted and the configuration with the changed atomic states is used as the initial state in the next step.

If $E > 0$, then the probability, as a new state will be accepted, is:

$$P(E) = exp(-E / kT),$$

where k - is Boltzmann constant, T -parameter "temperature".

Using the system energy as a target function and defining the system states with $\{x_i\}$, the Metropolis procedure generates a series of states for a given optimization problem at a given temperature.

The BM together with the SA can be used to solve optimization problems. To understand SA as an optimization method, the energy surface can be imagined as shown in Fig. 2. The ball will always look for a way down when starting from an arbitrarily chosen point. If such a system is disrupted by acting on it in some way (e.g. shaking), the ball will most often move from A to B, as the energy barrier is lower on the A side. If this exposure is slight, then it is obvious that the ball will move more often from A to B not from B to A. If the exposure is strong, the ball will cross the barrier faster and more often and it can move from both A to B and from B to A.

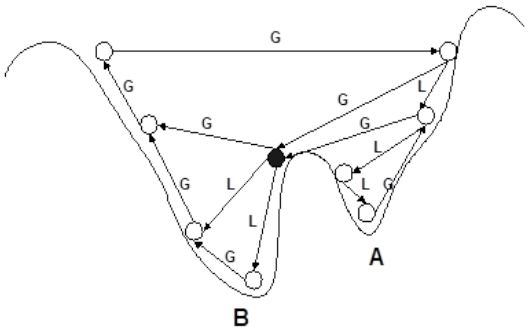


Fig. 2. Energy surface (G- global minimum, L- local minimum).

However, if you want to influence the movement of the ball, a good compromise would be to start with a stronger exposure and gradually reduce it. This would ensure that at some point the ball would pass through the global minimum.

In order to use the SA method in practice, it is necessary to determine:

1) the objective function W (analogous to the energy surface), the minimization of which is the aim of the procedure.

2) a set of possible solutions according to the energy surface or to the state of physical system.

3) configuration state random change generator.

4) control parameter T, which characterizes the artificial system temperature, and cooling mode, which characterizes how the temperature will be lowered.

The SA algorithm is based on Boltzmann's probabilistic distribution $Pr(E)$[11]. This expression states that if the system is in thermal equilibrium at temperature T, its energy is likely to be distributed between all the different energy states E. Even at low temperatures, there is a possibility that the system may be in a high energy state. The system has a corresponding probability of moving from a local energy minimum state to a better, more global minimum.

The steps of the SA algorithm in the pseudo-notation form are shown in Fig. 3.

```
(1)   T=T0;
(2)   While (T>Tfreeze)
(3)     Do until (Thermal equilibrium is reached) {
(4)           select (Config. i -> Config. j);
(5)           if(ΔWij<0) then
(6)             accept solution (Config. j);
(7)           else
(8)             r=random number [0,1);
(9)             if (exp(-ΔWij/T)>r) then
(10)              accept solution (Config. j);
(11)            else
(12)              reject solution (Config. i);}
(13)        T=T*Tf;}
```

Fig. 3. SA algorithm execution steps.

Here: T_0 – initial temperature; W_i – current configuration; W_j – selected configuration; T_f – decrease temperature; $exp(-W_{ij}/T)$ – Bolcmann factor.

SA differs from other gradient descent optimization procedures in that it does not "get stuck" in the local minimum found. Although SA is a relatively slow procedure, it guarantees finding the optimal global solution.

The main purpose of this article is to show the capabilities of the SA algorithm in solving practical tasks. One of the authors has already carried out research on a similar topic [12], [13]. In this article, the deficiencies found in the article [12] have been corrected and the description of the operation of the SA algorithm has been supplemented. An example of SA demonstration is taken from [13]. In the following, the essence of SA will be discussed in more detail.

II. Boltzman's Machine Operation Principle

To understand the principles of BM operation, in future we will use the notation and a network with three nodes (neurons) from [5] (see Fig. 4):

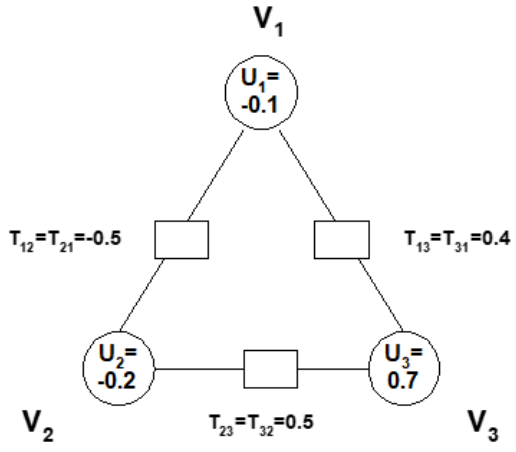


Fig. 4. The simple net nodes.

For the above net, the following holds:

$$V_i = 1, if \sum_{i \neq j} T_{ij} V_j > U_i \text{ and } V_i = 0, if \sum_{i \neq j} T_{ij} V_j < U_i \quad (2)$$

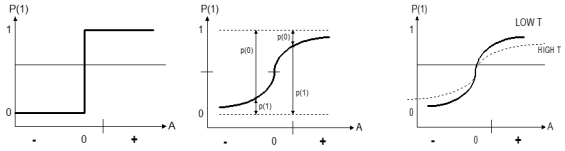
where V_i - activated state of the neuron,

U_i - threshold of the neuron; T_{ij} - weight coefficients between neurons i and j.

$$\sum_{i \neq j} T_{ij} V_j - U_i \quad (3)$$

is the activation of neuron.

The temperature effect can be shown as a change in probabilities (see Fig. 5). (BFPF - Boltzmann probability activation function).



(a) – threshold function (b) - BFPF (c) - BFPF

Fig. 5. The "temperature" effect.

Hinton [3] showed that Boltzmann function correctly characterizes this effect:

$$p(1) = \frac{1}{1 + e^{\frac{-A}{T}}} \quad (4)$$

We will further use this formula to determine BFPF. This function is shown in Fig. 6 for temperatures 0.5 and 0.25.

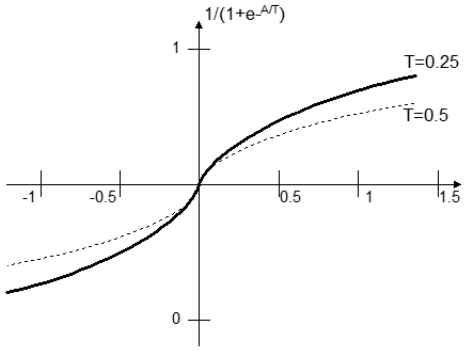


Fig. 6. "S"- shaped BFPF.

BM characteristics require:

1) For each state $V_1V_2V_3$ calculate the activation function according to the formula (3).

For example: $V_1V_2V_3 = 010$:

$$A_1 = T_{12}V_2 + T_{13}V_3 - U_1 = -0.5 + 0.1 = -0.4$$
$$A_2 = T_{12}V_1 + T_{23}V_3 - U_2 = 0 + 0 + 0.2 = 0.2$$
$$A_3 = T_{13}V_1 + T_{23}V_2 - U_3 = 0.5 - 0.7 = -0.2$$

2) For each neuron, the probability is calculated using formula (4) at different temperatures $[p(0) = 1 - p(1)]$ (see Table 1).

TABLE 1 PROBABILITIES AT DIFFERENT TEMPERATURES

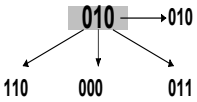
Neuron number	**T=0.25**		**T=1.0**	
	p(1)	***p(0)***	***p(1)***	***p(0)***
1	0.17	0.83	0.4	0.6
2	0.69	0.31	0.55	0.45
3	0.3	0.7	0.45	0.55

3) Using the values from point 2), it is necessary to calculate the transition probabilities to other states. In the general case - if the network consists of N elements - you can stay in the same state or go to N other states. For example, from state 010 the following transitions can be obtained:

The transition probabilities can be calculated by the formula:

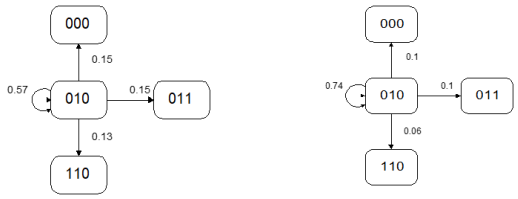
$$[V_j(p(1)_j + (1 - V_j)p(0)_j] / 3 \qquad (5)$$

We define for T=1:



010 -> 110 - $p(1)_1$=0.13
010 -> 000 - $p(0)_2$=0.15
010 -> 011 - $p(1)_3$=0.15
010 -> 010 - p=0.57

The result of applying this formula for state 010 for each neuron for various temperatures is shown in Fig.7.



(a) Boltzmann behavior (T=1.0) (b) T=0.25

Fig. 7. Transition probabilities for different temperatures.

4) Having obtained transition diagrams for all states, it is possible to draw a BM state diagram for each temperature. In practice, this turns out to be a laborious process, so another method is used. A chain of events $S_0, S_1, S_2, \dots S_{m-1}$ is given and a system is known for which these events that follow each other with known probabilities $p(i,j)$. The system can be represented by an $m \times m$ matrix. This method is known as Markov chain and makes it possible to find out the probability of system position in any state and at any time. The results are shown in Fig. 8. and Fig. 9. The shaded column is the state used for the example.

If the probability at time t is equal to $P_i(t)$, then the probability $P_j(t+1)$ of being in state S_j at time $t+1$ can be calculated using the formula:

$$P_i(t+1) = \sum P_i(t)p(i,j) \qquad (6)$$

Next State	CURRENT STATE							
	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7
S_0	0.55	0.31	0.1	0	0.13	0	0	0
S_1	0.02	0.08	0	0.02	0	0.04	0	0
S_2	0.23	0	0.74	0.23	0	0	0.27	0
S_3	0	0.31	0.1	0.58	0	0	0	0.17
S_4	0.2	0	0	0	0.71	0.26	0.26	0
S_5	0	0.3	0	0	0.08	0.47	0	0.1
S_6	0	0	0.06	0	0.08	0	0.24	0.1
S_7	0	0	0	0.17	0	0.23	0.23	0.63

Fig. 8. Markov chains for T=0.25.

Next State	CURRENT STATE							
	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7
S_0	0.53	0.22	0.15	0	0.16	0	0	0
S_1	0.11	0.35	0	0.11	0	0.13	0	0
S_2	0.18	0	0.57	0.18	0	0	0.2	0
S_3	0	0.22	0.15	0.54	0	0	0	0.17
S_4	0.18	0	0	0	0.56	0.19	0.2	0
S_5	0	0.21	0	0	0.14	0.5	0	0.15
S_6	0	0	0.13	0	0.14	0	0.42	0.15
S_7	0	0	0	0.17	0	0.18	0.18	0.53

Fig. 9. Markov chains for T=1.00.

For example, knowing that the probabilities of being in the time period $t = 0$ in any state are equal to 0.125 (i.e. 1/8). Then the probability of the system being in state S_3 can be calculated (see Fig. 9):

$$P_3(1) = P_0(0)p(0,3) + P_1(0)p(1,3) + P_2(0)p(2,3)$$
$$+P_3(0)p(3,3) + P_4(0)p(4,3) + P_5(0)p(5,3)$$
$$+ P_6(0)p(6,3) + P_7(0)p(7,3) =$$
$$= 0.125 * 0 + 0.125 * 0.22 + 0.125 * 0.15 +$$
$$+ 0.125 * 0.54 + +0.125 * 0 + 0.125 * 0 +$$
$$+ 0.125 * 0 + 0.125 * 0.17 =$$
$$= 0.125(0.22 + 0.15 + 0.54 + 0.17) = \mathbf{0.135}.$$

III. SIMULATED ANNEALING COUNTING

Using the possibility to calculate the probabilities of network nodes in any state and at any time, we can see what happens if the temperature of network changes. Let us turn to formula (6) and, using the Markov chain for $T = 1$ and $T = 0.25$, calculate the probabilities of finding network states at time t. The results are shown in Fig. 10.

T.	Time	P(0)	P(1)	P(2)	P(3)	P(4)	P(5)	P(6)	P(7)
1.00	1	0.13250	0.08750	0.14125	0.13500	0.14125	0.12500	0.10500	0.13250
1.00	2	0.13326	0.07630	0.14966	0.13586	0.14770	0.12052	0.10211	0.13457
1.00	3	0.13350	0.07198	0.15417	0.13548	0.15002	0.11715	0.10321	0.13450
1.00	4	0.13372	0.07001	0.15694	0.13498	0.15094	0.11487	0.10457	0.13398
1.00	5	0.13396	0.06899	0.15873	0.13461	0.15133	0.11336	0.10555	0.13345
1.00	6	0.13420	0.06843	0.15993	0.13436	0.15151	0.11238	0.10617	0.13302
1.00	7	0.13441	0.06810	0.16074	0.13421	0.15159	0.11172	0.10655	0.13268
0.25	8	0.13054	0.01528	0.20866	0.13741	0.19140	0.09850	0.06050	0.15671
0.25	9	0.12228	0.01052	0.23237	0.13194	0.20334	0.08186	0.05802	0.15866
0.25	10	0.12019	0.00920	0.24609	0.13000	0.20520	0.07376	0.06000	0.15456
0.25	11	0.12024	0.00869	0.25585	0.12913	0.20451	0.06930	0.06104	0.15024
0.25	12	0.12100	0.00845	0.26317	0.12872	0.20314	0.06656	0.06138	0.14658
0.25	13	0.12189	0.00833	0.26875	0.12851	0.20169	0.06473	0.06143	0.14366
0.25	14	0.12272	0.00826	0.27306	0.12842	0.20038	0.06342	0.06137	0.14137
0.25	15	0.12341	0.00822	0.27639	0.12838	0.19926	0.06246	0.06128	0.13959

Fig. 10. Network states at time t.

Starting with equal probabilities (1/8) the system reaches time=7 at temperature $T = 1$. Having experimentally verified the following steps, it is clear that

at this temperature the probabilities practically do not change further. According to Hinton, this phenomenon is called "Thermal equilibrium". The probabilities begin to change when the temperature changes. Fig. 10. shows that the temperature drops to 0.25. Thermal equilibrium is reached again at time=15. If at this point we go to $T = 0$, we can get the final state of the network:

T.	Time	P(0)	P(1)	P(2)	P(3)	P(4)	P(5)	P(6)	P(7)
0	28	0	0	0.494	0	0.313	0	0	0.193

At the end of the annealing process, the system reaches a stable position. If the initial conditions of the network from point 2) are met, then it is clear that the state S_2 with the lowest energy (-0.2) has the highest final probability - 0.494; S_4 - with energy -0.1 at the beginning has a final probability - 0.313; and finally - S_7 has the smallest final probability. For all other states, the final probabilities are zero.

The purpose of Boltzmann approximation was to prove that the final probabilities in a partial state strongly depend on the state energy.

IV. Using the SA Method for Optimization Purposes

The SA method is widely used in many combinatorial optimization tasks. It is used in graph theory, neural networks and other applications. As an application of the SA algorithm, the well-known combinatorics problem - the traveling salesman problem (TSP) - is proposed, the goal of which is to find the shortest path between N cities - visiting each city only once and returning to the original city at the end. It is a fairly well-known problem in combinatorics, which can be solved by various combinatorics or graph theory techniques. Methods of solving TSP with the SA algorithm have also been reviewed in the literature [14], [15].

The task of TSP is to minimize the objective function in all possible permutations. If n cities are located in 2-dimensional Euclidean space, then d_{ij} is the Euclidean distance between cities i and j, then C_{ij} is the shortest path for the given distance matrix D.

In order to use the SA algorithm for this type of task, some concepts need be introduced. For each path, we can define a neighbour as the set of paths that can be reached from the current path during one transition. Such a mechanism of neighbour structures for TSP is called k-opt transitions.

For the purpose of the experiment, a study was carried oud: to find the shortest path between 8 milk processing companies. It is necessary to solve the task of TSP-8 with the help of the SA method, i.e., find the shortest path between 8 objects. Locations of objects are given with GPS coordinates.

In this case, the SA algorithm executes in 20 steps, i.e., as a result of the experiment, it was determined that the state of thermal equilibrium was reached in the $20-th$ step (see Fig. 11). The shortest path calculated by the SA algorithm was 648 km (see Fig. 12.).

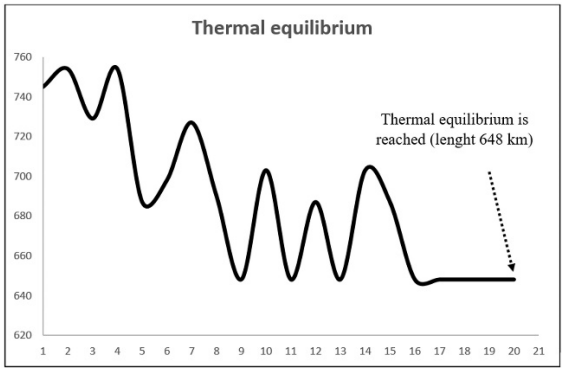


Fig. 11. Thermal equilibrium is reached.

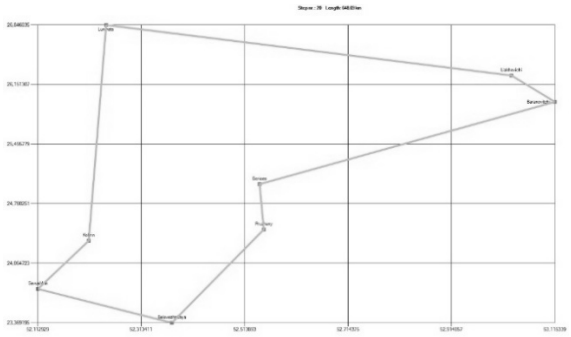


Fig. 12. The shortest path between objects.

V. Conclusion

This article describes an optimization method called simulated annealing. The SA method is widely used in various combinatorial optimization tasks. SA is a stochastic optimization method that can be used to minimize a given cost function when a combinatorial system with multiple degrees of freedom is used. This method allows you to find a global extremum for a function that has local minima. This article demonstrates the application of the SA method to a well-known combinatorial analysis problem, the Traveling Salesman Problem, and performs an experiment to find the shortest path between 8 companies.

The SA method is used to implement the BM operation. The purpose of this article was to show the capabilities of the SA algorithm in solving practical combinatorics problems.

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From Industry 4.0 Paradigm Towards Industry 5.0

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Abstract. **In 2021. European Commission formally called for a fifth industrial revolution (Industry 5.0). Discussions by participants from all over Europe in two virtual workshops organised by Directorate "Prosperity" of Directorate-General for Research and Innovation on 2 and 9 July 2020 resulted in the document "Industry 5.0: Towards a Sustainable, Human-centric, and Resilient European Industry" issued on 4 January 2021.**
Industry 5.0 recognises the power of industry to achieve societal goals beyond job creation and growth to become a resilient provider of well-being, making production respect the limits of the planet and placing the well-being of industrial workers at the centre of the production process. Industry 5.0 complements the existing Industry 4.0 paradigm as research and innovation drives the transition to a sustainable, human-centred and resilient European industry. Given that technological advances are changing the way value is created, exchanged and distributed, there is an urgent need to design these technologies to support future societal values. The emergence of these changes and the questions closely linked to technological innovation require industry to rethink its position and role in society.
The purpose of this article is to analyse the assumptions of Industry 5.0 and compare them with the Industry 4.0 paradigm.

Keywords: Industry 5.0, Industry 4.0, management, development.

I. INTRODUCTION

The Industrial Revolution can be defined as the transformation of traditional industrial practices into new techniques dominated by the technologies available at the time. The first three industrial revolutions were driven by mechanisation, electrification and automation respectively, which gradually transformed the agricultural economy into a manufacturing-based economy [1]. This helped to improve the lifestyles of factory workers and the health care system, which improved the overall quality of life. Industries that have adapted to the changes have seen increased production, improved competitive advantages and cross-border business opportunities. While we are now living in a time when the fourth industrial revolution (also known as Industry 4.0) is unfolding all around us, the world is ready for the next big leap, the fifth industrial revolution or Industry 5.0. [2].

Innovations in technology are transforming both traditional products and business procedures. The digital revolution is transforming technology into a digital format. Industry 4.0 is a combination of physical assets and advanced technologies such as artificial intelligence, IoT, robots, 3D printing, cloud computing, etc. Organisations that have embraced 4.0 are flexible and prepared to make data-driven decisions [3]. Industry 5.0 is the upcoming previous generation technology for efficient and intelligent machines. The purpose of this paper is to analyse the assumptions of Industry 5.0 and compare it with the Industry

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4.0 paradigm. The paper is theoretical and conceptual in nature, and typical research methods for this type of study were used: critical literature analysis, document analysis, logical operations.

II. INDUSTRY 4.0 OR ALREADY 5.0 - PILLARS OF THE CONCEPTUAL APPROACH

The ongoing fourth industrial revolution, commonly referred to as Industry 4.0 or 4IR, is evolutionarily based on the third industrial revolution, which relied on transistors, sensors and microelectronics to generate data. The term Industry 4.0 was first used by German professor Wolfgang Wahlster in 2011 at the Hannover Fair [4], [5], [6]. The term encompasses the computerisation of production, in which advanced digital technologies are combined with industrial machines and processes. The interconnection of these technologies with the production setup aims to achieve operational efficiency, productivity and automation to the highest possible degree [7], [8]. This in turn creates a manufacturing ecosystem that is smart, connected and data-driven.

The basic model of Industry 4.0 can be broken down into digital or computing technologies that are connected to the systems of the physical world. While artificial intelligence, machine learning, big data, cloud computing and cyber security are part of the core computing technologies, other technologies such as automation and robotics, IoT, CPS and AM are part of the physical. Together, these technologies realise the benefits of Industry 4.0 systems, enabling the agile, flexible, on-demand manufacturing that is an essential part of smart manufacturing or smart factories. While there are tremendous benefits for industry in implementing these technologies to achieve competitive advantage and higher operational efficiency [9], [10], [11].

While the world of science and practice is still trying to adapt and exploit the potential of Industry 4.0, policy makers, industrialists and scholars have started to discuss the next industrial revolution - Industry 5.0 [12], [13]. If Industry 4.0 is about digitally connecting machines to enable a seamless flow of data and the highest possible optimisation, Industry 5.0 is considered to, as it were, 'bring people back into the game' for collaboration and bring people into manufactured products, while focusing on such an important aspect as sustainable production [14], [15], [16].

Rather than treating technology as a key element, the European Commission [17] sees three key factors as being at the heart of the new Industry 5.0 industrial paradigm:

1. A human-centred approach that places human needs at the centre of the production process, asking what technology can do for workers and how it can be useful.
2. Sustainability, which focuses on reusing, repurposing and recycling natural resources and reducing waste and environmental impact.
3. Resilience, which means bringing robustness to industrial production. This robustness provides support through flexible processes and resilient production capacity, especially in the event of a crisis.

In the European Commission's view, Industry 5.0 is a necessary evolutionary step of Industry 4.0 due to [18], [19]:

1. Industry 4.0 is not the right framework to achieve Europe's 2030 goals, because the current digital economy is a winner-take-all model, creating a technological monopoly and gigantic wealth inequality.
2. Industry 5.0 is not a technological leap forward, but a way of looking at the Industry 4.0 approach in a broader context, providing a regenerative purpose and focus for the technological transformation of industrial production for the benefit of people, planet and prosperity.
3. Industry 5.0 is a transformational model that reflects the evolution of our thinking after the COVID-19 pandemic, taking into account the lessons from the pandemic and the need to design an industrial system that is inherently more resilient to future shocks and truly integrates social and environmental principles.

In early 2022. European Commission took a stance against Industry 4.0, arguing that this paradigm cannot be considered an appropriate framework for dealing with the prevailing climate crisis and social tensions [18]. According to the position presented, Industry 5.0 represents a new vision for the industry, redefining the role and functionality of value chains, business models and digital transformation in a hyper-connected business environment. As demonstrated in studies [20], [21], [22], Industry 5.0 differs from Industry 4.0 in the following ways:

- Industry 5.0 values both performance-based competitiveness and sustainability;
- Industry 5.0 strengthens the human workforce by promoting a human-centred approach to technological development;
- Industry 5.0 develops technological innovations (such as smart renewable systems) in the field of environmental sustainability;
- Industry 5.0 promotes stakeholder primacy in technology management, innovation growth and sustainable performance management;
- Industry 5.0 refers to certain technologies and functional principles to extend the scope of corporate responsibility along the entire value chain.

There is a consensus in the literature that Industry 5.0 differs from previous industrial revolutions because it represents a stakeholder-driven socio-technological phenomenon that systematically shifts classic profit- and consumption-driven economic models to a circular economy, sustainability and sustainable development and economic value-creating models.

III. SUSTAINABLE INDUSTRIAL DEVELOPMENT FUNCTION 5.0

Industry 5.0 relies on the most disruptive technological innovations to achieve its core objectives of human-centredness, resilience and sustainability [23]. Among other things, Agenda 21 adopts Principle 1, stating that humans are agents of sustainable development and have the right to live healthy and productive lives in harmony with nature [24]. This transformation is intended to promote the development of society, influence the reduction of climate change and environmental degradation and thus improve the quality of life for present and future generations. In the Industry 5.0 concept, the human factor regains its rightful place at the centre of the production process. According to this approach, it is technology that should serve man, not the other way around, and the aim should therefore be to ensure full cooperation between humans and machines [15]. Industry 5.0 complements the existing Industry 4.0 paradigm, as research and innovation drive the transition to a sustainable, human-centred and resilient European industry [25]. The European Economic and Social Committee's Consultative Commission on Transition [26] identified the key challenges of Industry 5.0 at a conference on 22.11.2018. Human-robot collaboration is a marker of the new economy, where the role of humans is changing, as there will be jobs operated autonomously by robots. The challenge will be the social and ethical risks associated with the new industrial revolution, in which humans will increasingly be replaced by machines to create society 5.0. Society 5.0 is a new social model with humans at its centre. Humans are the creators of content and analyse networked data, but they cannot share knowledge and information effectively without digitalisation and automation [27], [28], [29]. Therefore, there is a need for infrastructure and information systems connected to people in cyberspace and artificial intelligence to process data and generate results into virtual space. The new generation of development is a super intelligent society, based on data and knowledge. Such a human development trend is linked to smart manufacturing systems and social infrastructure [15].

IV. CONCLUSIONS

The notion of Industry 5.0 complementing and extending the distinctive features of Industry 4.0 suggests that they should be considered alongside each other, i.e. the coexistence of technology-based Industry 4.0 and value-based Industry 5.0. The growth and development model of Industry 5.0 is based on three fundamental pillars: Ecology-Human-Resilience. Industry 5.0 will benefit workers, entrepreneurs and the environment. Changing the current approach will not only increase production efficiency, but also make more rational use of available natural resources and provide better working conditions.

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The Heat Transfer and Magnetohydrodynamics Problem with Heat Source in Half Infinite 1-D Domain

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Abstract. **In this paper we consider the temperature and laminar flow of an incompressible conducting fluid past a non-conducting half-space. For the space approximation the finite differences method-finite difference scheme (FDS) and finite difference scheme with exact spectrum (FDSES) for solving the heat transfer and laminar flow initial boundary-value problem are used. This procedure allows reducing the problem to initial value problem for ordinary differential equations and the solution to the problem can be obtained numerically and analytically. The equation of the temperature is un-depending on the velocity and this function we can obtain in analytical form use the integral transform methods- Fourier and Laplace transforms.**

Keywords: 1-D MHD problems, FDS and FDSES methods, Fourier and Laplace transforms.

I. Introduction

Nature of fluids, hydrodynamics, differential equations, dimensional analysis, viscous flows and mathematical theory of fluid motion, useful in applications to both hydrodynamics is described in [6], [5]. Effective finite difference and conservative averaging methods for solving problems of mathematical physics are described in [16].

The distribution of electromagnetic fields, forces and temperature induced by the system of the alternating electric current in the conducting cylinder has been calculated in [15].

The 3-D MHD problem is analysed numerically in [13] and for solving of MHD problem of viscous incompressible fluid the special monotonous difference schemes (FDS, FDSES and others) have been developed in [14].

Using the hydrodynamics, magnetohydrodynamics (MHD) and heat transfer aspect [4], [8], [7], [9], [3] we consider simple problem of the laminar flow of an incompressible conducting fluid past a non-conducting space $y \in (-\infty; +\infty)$.

The fluid flows through this space and in contact with the plane xz-plane. A constant magnetic field of strength H_0 acts in the z-direction. The magnetics Reynolds number of the flow R_m is assumed to be small [8]. Under these conditions all the considered functions at a given point in the space depend only on its y-coordinate and time $t \in [0, t_f]$ (t_f is the final time) and $V = (u(y,t), 0, 0)$ is the vector velocity of the fluid with one component in x-direction.

The solutions of some problems of partial differential equations (PDE) with PBCs are obtained, using the method of lines (MOL) to approach the PDEs in the time and for discretization them in the space, applying the finite difference scheme with central differences of a second order of the approximation (FDS) and the finite difference scheme with the exact spectrum (FDSES).

II. Materials and Methods

In the present chapter the dimensional and dimensionless problems are considered. For this purpose, the integral transform methods, FDS and FDSES methods for solving the heat transfer problem and the

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problem of the laminar flow of an incompressible conducting fluid velocity is studied.

A. The Dimensional Problems

Being based on the above-mentioned assumptions, we have [5]:

1) the magnetic induction has one non-vanishing component $B_z = \mu H_0 = B_0 = const$

2) the Lorentz force $F = JxB$ has one component in x-direction is $F_x = -\sigma B_0^2 u$,

3) the compatibility relation is $\rho_\infty - \rho = \rho\beta_0(T - T_\infty)$,

4) the equation of motion

$$\frac{\partial u}{\partial t} = \nu\frac{\partial^2 u}{\partial y^2} + g\beta_0(T - T_\infty) - \frac{\sigma B_0^2}{\rho}u,$$

5) the energy or heat equation with the source term

$$\rho C_p\frac{\partial T}{\partial t} = k\frac{\partial^2 T}{\partial y^2} + Q,$$

6) let us introduce the following non-dimensional variables:

$$y' = \frac{U}{\nu}y, t' = \frac{U^2}{\nu}t, u' = \frac{u}{U}, p_r = \frac{C_p\nu}{k\rho},$$

$$M = \frac{\nu\sigma B_0^2}{\rho U^2}, Q' = \frac{\nu^2 Q}{kT_0U^2}, T' = \frac{T-T_\infty}{T_0},$$

$$Gr = \frac{\nu\beta_0 g(T - T_\infty)}{U^3}.$$

Here $\rho, \mathrm{H}, \mathrm{B}, \mathrm{J}, \beta_0, C_p, k, \sigma, Q, \nu, g$ are fluid density, vectors of magnetic field intensity, magnetic induction, conduction electric density, coefficient of volume expansion, specific heat at constant pressure, thermal conductivity, electric conductivity, intensity of the applied heat source, kinematics viscosity, acceleration due to gravity, $T_\infty, T_w, T_0 = T_w - T_\infty$ are temperature of the fluid away from the plane surface, temperature of the plane surface, reference temperature, p_r, Gr, M are Prandtl, Grashof and Magnetic (Stewart) numbers. This is the well-known Boussinesq approximation.

We shall consider a point-type heat source of the form $Q = Q_0\delta(y)H(t)$, where $\delta(\mathrm{y}), H(t)$ are δ - Dirac and Heaviside functions.

B. The Dimensionless Problem

The dimensionless problem for heat transfer and velocity equations is:

$$\begin{cases} p_r\dfrac{\partial T(y,t)}{\partial t} = \dfrac{\partial^2 T(y,t)}{\partial y^2} + Q_0\delta(y)H(t), y \in (-\infty,\infty), t > 0, \\ \dfrac{\partial u(y,t)}{\partial t} = \dfrac{\partial^2 u(y,t)}{\partial y^2} + GrT(y,t) - Mu(y,t), \\ T(y,0) = u(y,0) = 0, u(\pm\infty,t) = T(\pm\infty,t) = 0. \end{cases} \quad (1)$$

The equation of the temperature is un-depending on the velocity and this function we can obtain in analytical form use the integral transformation methods. We can also use FDS method by $\pm\infty \approx \pm L$, where approximately $L = 5$.

C. The Integral Transform Method for Solving of Heat Transfer Problem

Using the integral Fourier transform [2] $T_*(k,t) = (2\pi)^{-0.5}\int_{-\infty}^{\infty} T(y,t)\exp(-iky)\,dy$

we obtain

$p_r\frac{\partial T_*(k,t)}{\partial t} = -k^2T_*(k,t) + Q_0H(t)/\sqrt{2\pi}, k \in (-\infty,\infty), t > 0$ (2)

The solution by $T_*(y,0) = 0$ is

$T_*(k,t) = \frac{Q_0}{\sqrt{2\pi}}\frac{1-\exp(-\alpha k^2)}{k^2}$, (3)

where $\alpha = \frac{t}{p_r}$.

This solution we can obtain also with Laplace transform

$$T^*(y,s) = \int_0^\infty T(y,t)\exp(-st)\,dt.$$

Then from equation (1) follows

$$p_rsT^*(y,s) = \frac{\partial^2 T^*(y,s)}{\partial y^2} + Q_0\delta(y)/s$$

and from Fourier transform we get

$$p_rsT_*^*(k,s) = -k^2T_*^*(k,s) + \frac{Q_0}{\sqrt{2\pi}s}$$

or

$$T_*^*(k,s) = \frac{Q_0}{\sqrt{2\pi}s(p_rs + k^2)}.$$

Using the inverse Laplace transform we obtain (3).

With the inverse Fourier transform

$$T(y,t) = (2\pi)^{-0.5}\frac{Q_0}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\frac{1-\exp(-\alpha k^2)}{k^2}\exp(iky)\,dk$$

we get

$T(y,t) = \frac{Q_0}{\sqrt{2\pi}}\sqrt{\frac{2}{\pi}}F(\alpha)$, where

$F(\alpha) = \int_0^\infty \frac{1-\exp(-\alpha k^2)}{k^2}\cos(ky)\,dk, F(0) = 0.$

Using derivation with respect to parameter α we obtain the known integral

$F'(\alpha) = \int_0^\infty \exp(-\alpha k^2)\cos(ky)\,dk = \sqrt{\frac{\pi}{4\alpha}}\exp\left(-y^2/(4\alpha)\right)$ or

$$F(\alpha) = \sqrt{\pi/4}\int_0^\alpha \frac{\exp\left(-y^2/(4\xi)\right)}{\sqrt{\xi}}d\xi.$$

With transformation $s = \frac{y^2}{4\xi}$ follows:

$$F(\alpha) = \sqrt{\frac{\pi}{16}}|y|\int_{y^2/(4\alpha)}^\infty \frac{\exp(-s)}{s^{1.5}}ds.$$

Using the integration by parts

$$\int v\,du = uv - \int u\,dv, du = s^{-1.5}ds,$$
$$v = exp(-s),$$

$dv = -exp(-s)ds, u = -2s^{-0.5}$, we obtain

$$F(\alpha) = \sqrt{\frac{\pi}{16}}|y|\left(4\sqrt{\alpha}\exp\left(-\frac{y^2}{4\alpha}\right)/|y| - 2\int_{y^2/(4\alpha)}^\infty \frac{\exp(-s)}{s^{0.5}}ds\right).$$

Therefore, we have obtained the analytical solution in the form:

$$T(y,t) = Q_0\sqrt{2/\pi}\left(\sqrt{\frac{t}{2p_r}}\exp\left(-\frac{y^2p_r}{4t}\right) - |y|\sqrt{\frac{\pi}{8}}erfc\left(|y|\sqrt{\frac{p_r}{4t}}\right)\right),$$

$erfc(u) = \frac{2}{\sqrt{\pi}}\int_u^\infty \exp(-\xi^2)\,d\,\xi.$

D. The FDS and FDSES Methods and the Solution of the Heat Transfer Problem

We can construct the FDSES when in the representation for FDS, $A = WDW$ the diagonal elements of matrix D are replaced with the eigenvalues from the differential problem [11], [12].
For obtaining the temperature and velocity we consider uniform grid in the space $y_j = jh - L, j = \overline{0,2N}, Nh = L$.

Using the finite differences of second order approximation for partial derivatives of second order respect to y we obtain from the first equation of (1) the initial value problem for system of ODEs in the following matrix form

$$\dot{V}(t) + \frac{1}{p_r}AV(t) = \frac{Q_0}{p_r h}, V(0) = 0 \qquad (4)$$

where A is the 3-diagonal matrix of $2N-1$ order in the form

$$A = \frac{1}{h^2}\cdot[-1;\ 2;\ -1\,],$$

$V(t), \dot{V}(t)$ are the column-vectors of $2N-1$ order with elements $v_j(t) \approx T(y_j,t)), \quad \dot{v}_j(t) \approx \frac{\partial T(y_j,t)}{\partial t}, \quad j = \overline{1,2N-1}$.

The expression of the vector Av can be represented in following way

$$Av_j = -\left(v_{j+1} - 2v_j + v_{j-1}\right)/h^2, j = \overline{1,2N-1}, \quad (5)$$

where v is the column-vector of $2N-1$ order with elements

$$v_j, j = \overline{1,2N-1}, v_0 = v_{2N} = 0.$$

Using two vectors v^1, v^2 scalar product

$$[v^1, v^2] = h\left(\sum_{j=1}^{2N-1} v_j^1 v_j^2\right)$$

it is possible to prove, that the operator A is symmetrical and $[Ay, y] \geq 0$ [1].

The corresponding discrete spectral problem $Aw^k = \mu_k w^k, k = \overline{1,2N-1}$ have following solution $\mu_k = \frac{4}{h^2}\sin^2\frac{k\pi}{4N}$ (elements of the matrix D), $w_{i,j} = \sqrt{\frac{2}{L}}\sin\frac{\pi ij}{2N}$, $i,j = \overline{1,2N-1}$ (elements of the symmetrical matrix W).

Using the usual scalar product of two vectors for eigenvectors without the step h,

$(w^k, w^m) = \sum_{j=1}^{2N-1} w_j^k w_j^m = \delta_{k,m}$, $w_j^k = C_k\sin\left(k\pi(jh+L)/(2L)\right)$, we get $C_k = \sqrt{\frac{2h}{2L}} = \sqrt{\frac{1}{N}}$.

The solution of discrete boundary value problem $Av = f, v(-L) = v(L) = 0$, or of the finite difference scheme (FDS) with second order of approximation for the boundary value problem of differential equation (1D Poisson equation) $-u''(y) = f(y), u(-L) = u(L) = 0$,

we can write in following form $Av = WDW\,v = F$, where F is the column-vector of $f\left(y_j\right), j = \overline{1,2N-1}$.

The solution of discrete boundary value problem $Av = f, v(-L) = v(L) = 0$, or of the finite difference scheme (FDS) with second order of approximation for the boundary value problem of differential equation (1D Poisson equation) $-u''(y) = f(y), u(-L) = u(L) = 0$,

we can write in following form $Av = WDW\,v = F$, where F is the column-vector of $f\left(y_j\right), j = \overline{1,2N-1}$.
The solution of the spectral problem for the corresponding differential problem $-w''(y) = \lambda w(y), w(0) = w(2L) = 0$ is in following form:

$$w^k(y) = \sqrt{\frac{2}{L}}\sin\frac{k\pi y}{2L}, \lambda_k = \left(\frac{k\pi}{2L}\right)^2, (w^k, w^m)_* = \int_0^L w^k(y)w^m(y)dy = \delta_{k,m}.$$

We can construct the FDSES when in the representation $A = WDW$ the diagonal elements of matrix D are replaced with the eigenvalues λ_k from the differential problem. Then the matrix A is not in the 3-

diagonal form but this is full matrix and $WW = E, W^{-1} = W, A = WDW$, where $D = diag(\lambda_k)$.

The solution of the equation $WDWv = F$ we can obtain in the form $v = WD^{-1}WF$ or $v = A^{-1}$.

E. The FDS and FDSES Methods for Solving the Velocity of a Laminar Flow of an Incompressible Fluid

Using the finite differences of second order approximation (FDS) for partial derivatives of second order respect to y we obtain from the second equation of (1) the initial value problem for system of ODEs in the following matrix form

$$\dot{U}(t) + AU(t) + MU(t) = GrV(t), U(0) = 0, \quad (6)$$

where A is the 3-diagonal matrix of $N-1$ order, $U(t), \dot{U}(t), V(t)$ are the column-vectors of $2N-1$ order with elements

$u_j(t) \approx u(y_j(t)), \dot{u}_j(t) \approx \frac{\partial u(y_j,t)}{\partial t}, j = \overline{1, N-1}, v_j(t) \approx T(y_j(t)), j = \overline{1,2N-1}$.

The solution with FDSES method is obtained in the representation $A = WDW$ where the diagonal elements of matrix D are replaced with the eigenvalues λ_k from the differential problem.

Systems of ODEs (4), (6) are solved with Matlab routine "ode15s".

III. Results and Discussion

In the present chapter we have solved the 1-D boundary value problem for Poisson equation, and have calculated the temperature and velocity of the non-compressible liquid flowing under the influence of the magnetic field.

The solution of 1-D Poisson equation (chapter D) for function $f(y) = \pi^2 sin(\pi(y+L)/2)$ is in the form $v(y) = -4sin(\pi(y+L)/2)$.

We have for $y \in [-L, L], y(-L) = y(L) = 0, N = 20$ following maximal errors E_r : $E_rFDS = 0.0518$ for FDS and $E_rFDSES = 10^{-14}$ for FDSES see (Fig. 1., Fig. 2.). In the Fig. 2. the error E_rFDS is compared with the error E_rMat, obtaineed by matrix A solutions Av=F in the form $v = A^{-1}F$.

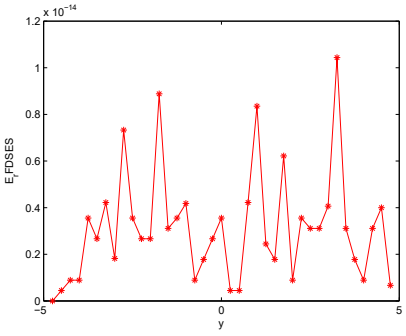

Fig. 1. The error for FDSES by N=20, L=5.

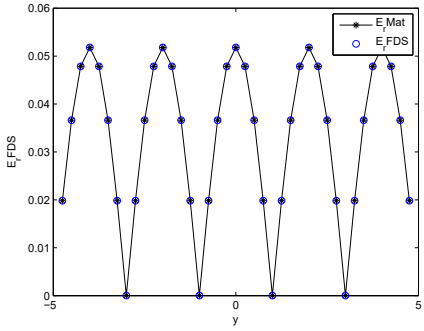

Fig. 2. The error for FDS and for matrix solution by N=20, L=5.

The solutions for temperature and velocity for $N = 40, Q_0 = 1, Gr = 10, M = 1, p_r = 0.71, t_f = 2$ using Matlab are obtained with following results:

a) the maximal values for temperature by FDS method $max(T_{apr})$ and by analytical (exact) method $max(T_{ex})$ are: $max(T_{apr}) = 0.9456$, $max(T_{ex}) = 0.9469$;
b) the maximal values for velocity using FDS method $max(u_{FDS})$ and by using FDSES method $max(u_{FDSES})$ are: $max(u_{FDS}) = 0.0310, max(u_{FDSES}) = 0.0311$.

The solutions of the temperature T(y,t) , $t \in [0, t_f]$ and $t = t_f$ are represented in Fig. 3.-Fig. 6., the corresponding solutions of velocity u(y,t) are represented in Fig. 7.-Fig. 10.

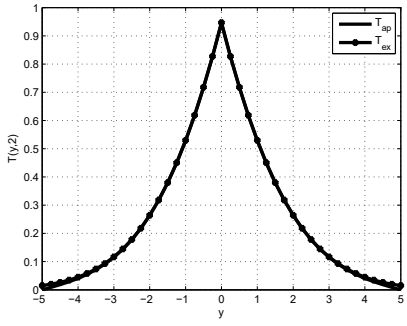

Fig. 3. The solutions $T(y, 2)$ depending on y.

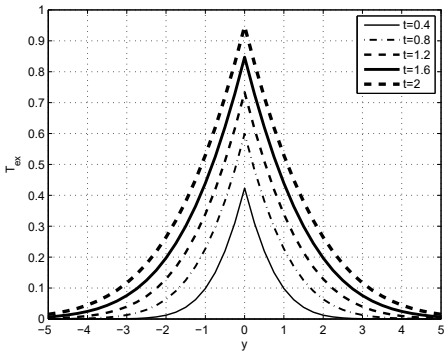

Fig. 4. The exact solutions $T(y,t)$ depending on t.

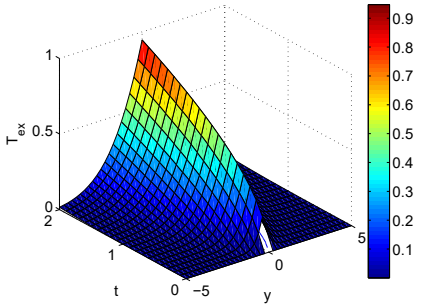

Fig. 5. The exact solutions $T(y,t)$ depending on y and t.

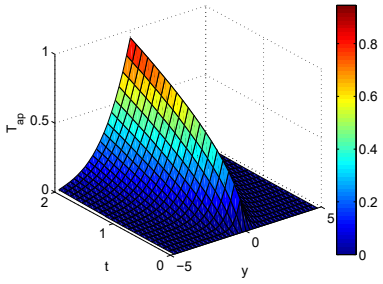

Fig. 6. The approximate solutions $T(y,t)$ depending on y and t.

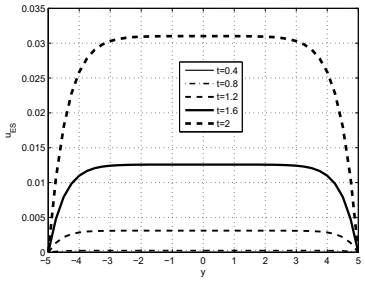

Fig. 7. The FDSES solutions $u(y,t)$ depending on t.

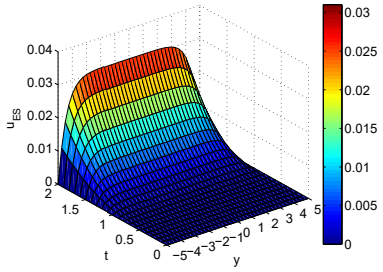

Fig. 8. The FDSES solutions $u(y,t)$ depending on y and t.

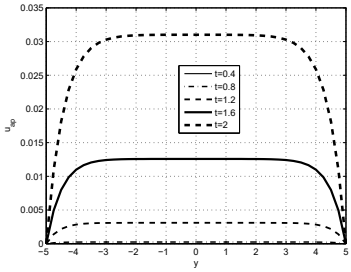

Fig. 9. The FDS solutions $u(y,t)$ depending on t.

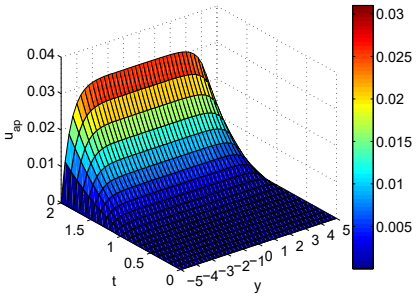

Fig. 10. The FDS solutions $u(y,t)$ depending on y and t.

We can see that the maximal values of temperature and velocity are concentrated around the point y=0. In the Fig. 11 the table (Tab) of maximum values u(y,t) depending on Gr and M for the values (1,2. . .10), $Q_0 = 1$, is presented. It is apparent that velocity decreases if M increases and velocity is growing up if Gr and temperature increases. In turn, the temperature is growing up with increasing Q_0, for example, if $Q_0 = 10$, then $max(T_{ex}) = 9.470$

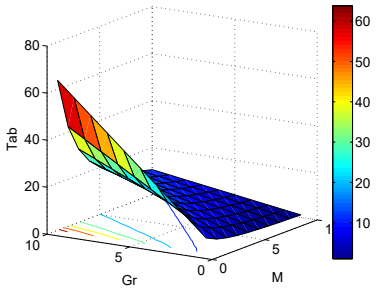

Fig. 11. The maximal values (Tab) of FDSES solutions for $u(y,t)$ depending on M, Gr.

IV. Conclusions

1. The approximation of corresponding initial boundary value problem of the system of PDEs is based on the finite difference schemes FDS and FDSES.

2. The solutions of temperature and velocity have been obtained depending on time and space parameters.

3. The max absolute value of difference between corresponding numerical and analytical solutions of velocity was approximately 0.1%.

4. The velocity and temperature have symmetrical profile depending on y, the maximum of temperature and velocity is concentred around the point y=0.

5. The solutions obtained by the MHD problems studied illustrate the simplicity and flexibility of the finite difference schemes FDS and FDSES in terms of their applicability and accuracy.

6. The system of parabolic type equations has been solved depending on time using Matlab routine "ode15s".

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Some Wi-Fi Access Points in the City of Sofia

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Abstract. **The purpose of this article is to present the results of a study of the number and type of Wi-Fi access points using applications for the collection, processing and analysis of data based on a sample collected in different areas and places with a significant concentration of people in a city Sofia, Bulgaria. Data on the number and type of access points were obtained by measurements taken at the respective locations. User equipment connects to different Wi-Fi access points located in different places in the city that are accessible. Data was collected for wireless access points that are fourth and fifth generation. Different generations in wireless networks have corresponding download and upload speeds and frequencies. In the article, the results are grouped and analyzed according to different characteristics.**

Keywords: Wi-Fi protocols and standards, Access points.

I. INTRODUCTION

The Internet plays an important role in today's communication, especially when efficiency is relied upon. Unlike other means of communication, the Internet is decentralized in such a way that any user can share, retrieve, sell or exchange goods and services with any other user within seconds..

Today, the Internet is a part of our daily life because of the great benefits we gain from it. A large number of companies are in the online space and are also engaged in e-commerce, which includes advertising, selling, buying, distributing products and providing products to customers. In addition, companies use the Internet for business-to-business and business-to-customer transactions. Individuals also use the Internet to communicate, entertain, share information, buy and sell goods and services [1].

With the widespread use of mobile terminals such as laptops, smartphones, mobile phones, Wi-Fi phones, personal digital assistants (PDAs), etc. the demand for wireless Internet access is clearly growing [8].

A wireless local area network (LAN) is one in which a mobile user can connect to a LAN via a wireless connection. Wireless local area networks (WLANs) conform to the 802.11 standards set by the Institute of Electrical and Electronics Engineers (IEEE) [8,9].

In the past few years, wireless access via Wi-Fi has grown rapidly and has become the dominant standard for wireless local area networks (WLANs). Because it operates in unlicensed frequency bands, anyone can set up a Wi-Fi network and cover an area typically from 15 to 250 meters with high-speed WLAN access and from there to the Internet [5,6,7].

Like other wireless access standards such as GSM or (Code-division multiple access) CDMA, Wi-Fi has also become a universal standard. As a result, the costs of Wi-Fi components decrease, and hence the volume and number of their use increases. Wi-Fi access is widespread and used in many different parts of the world [8,9].

Wi-Fi technology can be used to provide local area network and Internet access to devices that are within Wi-Fi range of one or more routers connected to the Internet. The coverage of one or more interconnected access points (APs, hotspots) can extend from a small area, such as a few rooms, to square kilometers. Coverage in the larger area may require a group of APs.

Wi-Fi provides services in private homes, businesses as well as in public places. APs can be set up for free or commercially, often using an access trap web page. Organizations, enthusiasts, authorities and businesses, such as airports, hotels and restaurants, often provide free or paid APs to attract customers, to provide services to

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promote business in selected areas. Routers often include a dial-up modem or cable modem and a Wi-Fi AP, set up in homes and other buildings to provide Internet access and networking for the structure.

In 2018, the Wi-Fi Alliance, a non-profit organization that owns the Wi-Fi trademark, began using a user-friendly generation numbering scheme for the publicly used 802.11 standard. Wi-Fi generations 0-6 refer to the 802.11b, 802.11a, 802.11g, 802.11n, 802.11ac and 802.11ax protocols [6,8,9].

Wireless LAN (WLAN) channels are often implemented using protocols from the IEEE 802.11 standard and equipment sold primarily under the Wi-Fi brand name. The radio frequency (RF) spectrum is vital to wireless communications infrastructure.

The 802.11 standard provides several different radio frequency bands for use in Wi-Fi communications: 900 MHz, 2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, 5.9 GHz, 6 GHz, and 60 GHz. Each range is divided into multiple channels. In the protocols, channels are numbered 5 MHz apart within a band (except for the 60 GHz band where they are 2.16 GHz apart) and the number is linearly related to the center frequency of the channel. Although the channels are spaced 5 MHz apart and their transmitters are typically at least 20 MHz wide, the protocols allow them to be linked together. Thus, wider ones are formed for higher throughput.

Countries apply their own regulations on allowable channels and maximum power levels in these frequency ranges [7,8,9].

The loaded of access points and analyzing performance of the university wireless network is verified in Wrocław University of Technology [2].

The optimization of the performance of wireless networks that use the 802.11ac wireless networks communication protocol by Markov chains and ant colony optimization models were analyzed [3].

Performance of Wi-Fi network in the cases of fading, flat fading and dispersive fading are discussed [4].

This article presents and discusses the results of measurements made of access point channels to a wireless network in public places where there is a gathering of a large number of people.

II. MATERIALS AND METHODS

The measurements were carried out in the period from 14.11.2022 to 26.11.2022 in the capital of Bulgaria - the city of Sofia with User Equipment (UE) - Samsung S20 fe with the operating system Android 13 using the mobile application Wi-Fi Monitor+ version v1.6.1 pro. [5].

The mobile application has the ability to display advanced information about Wi-Fi accessible networks of different generations and different protocols of the 802.11 standard, monitor the status and channels of the Wi-Fi TD. The information is presented and viewed in different sections: Fig.1, Fig.2 and Fig.3

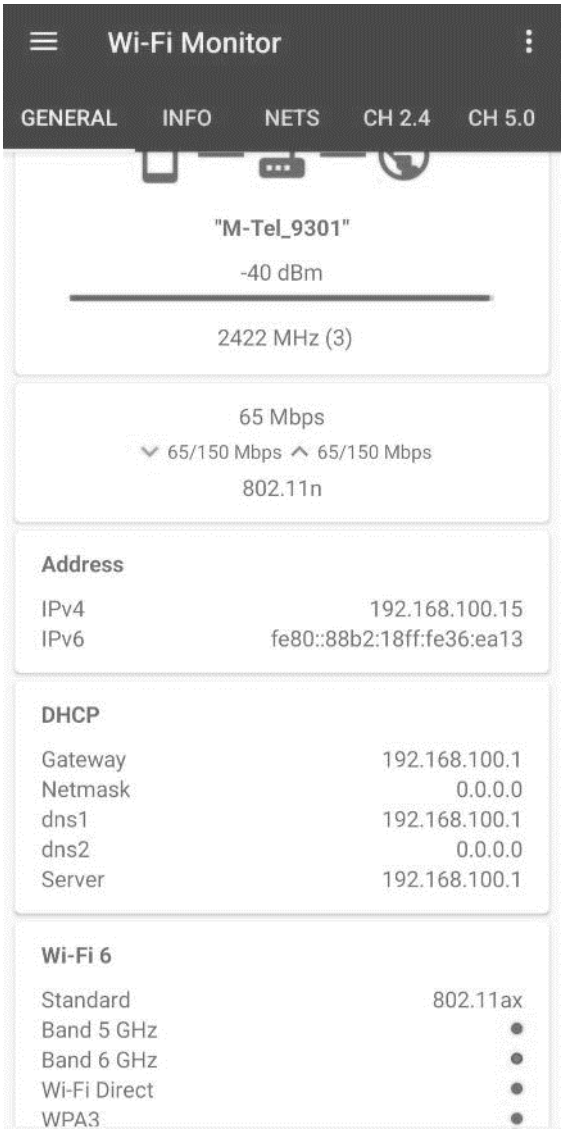

Fig. 1 Section General of application Wi-Fi Monitor +.

The GENERAL section shows the current network to which there is a connection at the moment, its power expressed in decibel-milliwatts (dBm), download and upload link speed, the specific protocol, IPv4 and IPv6 addresses, information about the Dynamic Host Configuration Protocol (DHCP), and the available options for connecting the terminal to different types of Wi-Fi networks.

The INFO section shows the identifier of the connected wireless network (SSID), the IPv4 and IPv6 used, the theoretical maximum data transmission speed between the terminal and the router (Link Speed), the Wi-Fi protocol of the connected network, frequency and connection channel, signal strength, connection level in percentage, DHCP protocol information.

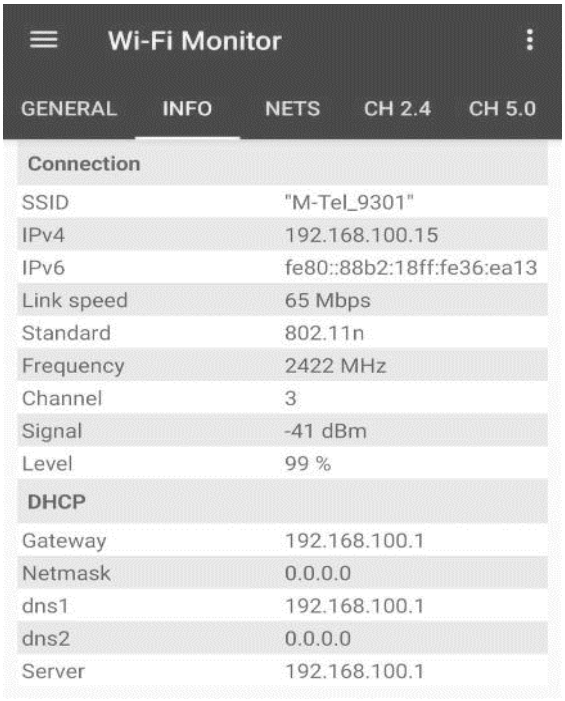

Fig. 2 Section Info of application Wi-Fi Monitor +.

The NETS section shows the available Wi-Fi networks with their identification, unique name, power, channel frequency and its number, channel width, protocol, security protocol used, MAC address of the source-manufacturer and manufacturer name of the router you connect to, if available [5].

Section CH 2.4 shows the available protocols of the 802.11 standard with a frequency of 2.4 GHz.

The CH 5 section shows the available protocols of the 802.11 standard with a frequency of 2.4 GHz.

The different protocols of the IEEE 802.11 standard also mean different generations of Wi-Fi and have different capabilities and speeds. Each of them has a different frequency and channel width of operation. [8,9]

In 2018, the Wi-Fi Alliance began using a standardization-friendly and user-friendly scheme to number the generations of public use networks of 802.11 protocols [7, 8,9].

According to Table 1, with each subsequent generation, the data transfer rate and the frequency used in the network increase. For frequencies of 2.4 GHz, the signal is spread over a greater distance, but the data transmission is at a lower speed. A Wi-Fi network with this frequency has 13 working channels for Europe with a channel width of 20 MHz.

Fig. 3 Section Nets of application Wi-Fi Monitor +.

TABLE 1 WI-FI GENERATIONS

Generation	IEEE Standard	Adopt.	Maximum Linkrate (Mbit/s)	Radio Frequency (GHz)
Wi-Fi 6E	802.11ax	2020	1376 to 46120	6[14]
Wi-Fi 6		2019	574 to 9608	2.4/5
Wi-Fi 5	802.11ac	2014	433 to 6933	5[15]
Wi-Fi 4	802.11n	2008	72 to 600	2.4/5
Wi-Fi 3	802.11g	2003	6 to 54	2.4
Wi-Fi 2	802.11a	1999	6 to 54	5
Wi-Fi 1	802.11b	1999	1 to 11	2.4
Wi-Fi 0	802.11	1997	1 to 2	2.4

It is more susceptible to interference than the network that uses the 5GHz frequency. Built-in networks with an operating frequency of 5 GHz have about twice the link distance of 2.4 GHz. Wi-Fi 5 GHz signals do not propagate as well, compared to a 2.4 GHz network. In addition, 5GHz Wi-Fi has higher speeds and is capable of more working channels - 53 for Europe. In addition, channel widths of 20, 40, 80 and 120 MHz are used and such networks are less susceptible to interference [8,9].

According to the characteristics of the different generations and protocols of the 802.11 standard, it is clear that in order to cover a larger area and provide it with high speeds, more routers and antennas should be used, which are separate or connected in different configurations.

III. RESULTS AND DISCUSION

The research was done in places with different numbers of APs next to Wi-fi networks. Each of them is characterized by the fact that it uses one of the protocols of the 802.11 standard. At the measurement sites, the signal has a certain power, channel width and frequency, according to the specific protocol.

In the study, the results from the different locations are sorted into categories based on the number of APs available and the protocol used to access the network.

Table 2 shows the number of APs at the respective locations for 802.11n (4G), 802.11ac (5G) and 802.11ac (6G). The data is obtained from the NETS section. The first column from table 2 shows the exact address, and the total column the total number of all APs on it.

TABLE 2. NUMBER OF ACCESS POINTS.

Place	802.11n	802.11ac	802.11ax	total
st. Kaufland bul.Totleben	26	3	1	30
st. Kaufland2 bul. Totleben	5	2	52	59
Streetbar&co bul. Vitosha 12	10	4	0	14
bus stop Pirogov	10	4	0	14
st. Billa Hipodruma	31	2	1	34
Bulgarian National Bank	17	19	1	37
bul. Vitosha 1	26	1	1	28
Military Academy "G.S.Rakovski"	10	3	0	13
entranceof National Palace Of Culture	22	35	1	58
bul. Graf Ignatiev 1	30	30	3	63
playground housing estate Zona B-5-3	10	4	0	14
checkout st. Kaufland bul.Totleben 36	4	2	46	52
coffee bar Military hotel Shipka	10	4	0	14
entrance of Ministry of Health	16	28	8	52
entrace of Department of Justice	21	5	5	31
entrance of Ministry of Finance	24	9	3	36
Mall "Mall of Sofia" first floor	12	3	0	15
Mall "Mall of Sofia" second floor	12	3	0	15
Mall "Mall of Sofia" third floor	12	3	0	15
Mall "Serdika" first floor	25	35	14	74
Mall "Serdika" second floor	17	18	2	37
Mall "Serdika" third floor	18	35	9	62
entrance of National theater "Ivan Vazov"	13	3	1	17
entrance of bulding of National Assembly	17	19	1	37
entrance of bulding of Presidency	17	19	1	37
entrance of Ministry of Defence bul. Totleben	11	0	0	11
entrance of University General Hospital "Pirogov"	10	1	0	11
entrance of Military Hotel "Shipka"	16	3	0	19
entrance of Courthhouse Sofia	19	7	0	26
entrance of DSK Bank Sofia	25	11	0	36
wi fi entrance of South Park Sofia	35	12	0	47
lobby of Military Hotel "Shipka"	14	1	0	15
near to Alexander Nevsky monument temple	17	19	1	37
entrance of National Gallery Sofia	28	4	0	32
center of South park Sofia	28	28	0	56

During the measurement period, data was collected on Wi-Fi networks from 35 places where there are often a large number of people. A different number of APs are available at each address. They are characterized by the fact that they offer the possibility of working in a wireless network of a different generation. At each significant location, the number of possible APs was counted. An identifier name was reported for each network. For each address, the received data is displayed and sorted, according to the protocol with which the different APs work. The total number of APs for each location was also received and recorded.

During the research in the city of Sofia, APs were observed next to Wi-Fi networks of three different generations (Wi-Fi 4, Wi-Fi 5 and Wi-Fi 6), operating in the respective protocols with different frequencies.

According to the measurements made and Table 2, 618 results are from the 4th generation wireless access

technology, 379 from the 5th generation and 151 of the obtained results are from the 6th generation Wi-Fi.

In percentage terms, 54% are from the 4th generation, 33% from the 5th and 13% from the 6th generation.

From the research done, it is clear that on average there are 32.8 APs on site, of which 17.7 are from the 4th generation, 10.8 from the 5th generation and 4.3 from the 6th generation of the Wi-Fi standard.

The largest percentage of all results are from 4th generation Wi-Fi. From the averaged results again the largest number are TD to the 802.11n standard or 4th generation protocol.

IV. Conclusions

Access point measurements were made to Wi-Fi networks in 35 places with a large number of people. From the data obtained, the largest percentage falls into the 4th generation (802.11n) category, while the corresponding values for other generations of Wi-Fi are less. From the obtained data, it was established that for one place, on average, nearly 33 APs of different generations of the Wi-Fi standard are available. The findings show that knowledge of the generation and operating frequencies of APs is important for accurate estimates of RF EMF exposure from mobile network equipment.

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Readiness of Latvia's Organizations for Advanced Analytics

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Abstract. **The advanced analytics is one of the core tools to provide competitive advantage, sustainable development and foster productivity of the organization. Digital transformation and advanced analytics are two key trends in the emerging age of data, analytics, and automation. Digital transformation is the process of transforming how businesses operate when faced with digital disruption. Advanced analytics is the application of predictive and prescriptive models to analyse large, complex datasets in order to make critical business decisions. The focus of the paper is to assess the maturity level of advanced analytics in the organizations of Latvia by region, size and industry. Assessment was done by several domains like Organization, People, Data, Analytics, Technologies. The quantitative online survey was performed to assess the readiness of Latvia's organizations for advanced analytics. The questionnaire was developed based on an academic literature review, reports and publications by researchers, analytical sector, industry experts and Author's professionals experience in advanced analytics industry. The overall readiness level of Latvia's organizations is 2.4 in 5 points scale. It differs by region, size of the organization and industry. Most of organizations do not have Analytics strategy, majority use spreadsheets based analytical tools, half of organizations use mostly only internal data, more than third part of organizations do not have any analytical resources. It leads to conclusion that majority of Latvia's organizations are far from ability to improve productivity, be able to maximize the potential of the digital environment, to exploit data to make data-driven and automated decisions and are far from 21st century digital opportunities. Thus, puts under danger the sustainability of the organizations itself.**

Keywords: advanced analytics, analytics maturity, analytics maturity assessment.

I. INTRODUCTION

There is no one size fits all answer to the question of how ready an organization is for advanced analytics. It is largely dependent on the specific needs, resources, and capabilities of the organization in question. The advanced analytics is one of the core tools to provide competitive advantage, sustainable development and foster productivity of the organization [1].

In general, organizations need to have a solid understanding of the data they have and what questions they need to answer. They should have an access to skilled and experienced data scientists who can use advanced analytical techniques to create models and insights from their data. Additional resources may include sufficient computing power, storage, software and tools for data mining and analytics, as well as support for implementation and integration of the results.

Organizations also need the right culture and attitude towards analytics. Successful analytics initiatives usually require buy-in from the organization's leadership, which is needed to commit the necessary resources and prioritize analytics within the organization. Additionally, staff should be trained in the use of the necessary technologies and have the opportunity to experiment and explore their data to come up with meaningful insights.

Finally, organizations should have a clear vision of how advanced analytics can benefit the organization. A clear business case for the use of advanced analytics can help formally prioritize this effort and direct the investment of resources towards the most impactful areas of the business.

Europe Union cohesion policy has set a menu of 5 policy objectives supporting growth for the period 2021-2027 where the number one is "a more competitive and smarter Europe". The majority of funds will be provided

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for innovative and smart economic changes - research and skills development, support for entrepreneurship, digitization and digital connections [2].

Digital transformation and advanced analytics are two key trends in the emerging age of data, analytics, and automation. Digital transformation is the process of transforming how businesses operate when faced with digital disruption. Companies generally use digital transformation to either revolutionize entire industries or help them become more efficient and effective in their operations. Advanced analytics is the application of predictive and prescriptive models to analyse large, complex datasets in order to make critical business decisions. It includes the use of machine learning, deep learning, artificial intelligence, and other cutting-edge analytics technologies. By leveraging advanced analytics, companies can gain insight into customers, markets, processes and products, and use this data to make better decisions. This helps them to automate strategies that can improve performance and realize goals faster, more efficiently, and with greater accuracy.

Assessment of the advanced analytics ecosystem and realistic understanding of readiness level to use advanced analytics in daily decision is crucial for further development, competitions in the market and to reach the strategic goals of the organization. It is a base to allocate or attract investments for the future steps to adopt advanced analytics to make digitization process productive [3]. Analytics ecosystem can be described like the systematic computational analysis of data or statistics in a complex network or interconnected systems. [4]-[5]. In other words, the interconnected network of tools, technologies, and processes used to collect, store, process, analyse, and visualize data within an organization. It includes various components such as data sources, data warehousing and storage, data processing and analytics tools, data visualization and reporting tools, and various other supporting technologies and processes. The analytics ecosystem allows organizations to collect data from various sources, process it, and turn it into actionable insights that can be used to drive business decisions. The ecosystem can be composed of both proprietary and open-source technologies, and it can be customized to meet the unique needs of each organization. The primary goal of an analytics ecosystem is to enable organizations to make data-driven decisions based on insights derived from their data. By leveraging analytics tools and techniques, organizations can gain a deeper understanding of their business operations, customers, and market trends, and use this information to optimize their performance and drive growth.

The competition between organizations is very high and to ensure faster and smarter decision-making, organizations are forced to use advanced analytics to analyse the past, understand the present behaviour and predict and influence the future events, actions, decisions and behaviour. By implementing advanced analytics into operations, organizations significantly increase a control over daily decisions that ensures a higher potential to meet their business goals [6] – [7].

Considering the increasing demand for advanced analytics including automated decision making based on data or process automation the significance to understand the advanced analytics ecosystem maturity level in any country, industry or organization is topical. The analytics maturity assessment or detection of the analytics development level by several factors which are crucial to ensure proper analytics performance helps to identify strengths and weaknesses of the organization's analytics ecosystem and can provide detailed action plan step by step to move existing analytics ecosystem to the next level or level what is relevant to the organization to meet its strategic goals.

The paper aims to disclose the findings from the survey performed in the beginning of 2022 in Latvia where advanced analytics ecosystem were assessed to detect overall readiness level for the advanced analytics in the organizations in Latvia.

II. Materials and methods

Author performed the survey to assess the readiness of Latvia's organizations for advanced analytics. The questionnaire was developed based on an academic literature review, reports and publications by researchers, analytical sector, industry experts and Author's professionals experience in advanced analytics industry.

A. Global researches

Global researches and surveys about advanced analytics include Europe, but not all countries. Usually UK, France and Germany are represented. There are global level researches such a Network readiness index which is published annually by the World Economic Forum in collaboration with INSEAD, as part of their annual Global Information Technology Report [8]. This Index target to measure the degree of readiness of countries to exploit opportunities offered by information and communications technology, however it does not give understanding about advanced analytics development in specific country. General correlation is as higher index for the specific country as higher probability to have more advanced analytics ecosystem maturity.

There are very rare reports, surveys, researches which could be connected directly to the maturity of analytics, or advanced analytics and usage of advanced analytics about the Baltic States or Latvia. Several studies have addressed related and more global areas under the Smart Specialization Strategy of Latvia (2015) and following monitoring (2014-2020), but this only gives an idea whether there is a potential for analytics to be mature enough to adopt advanced analytics [9]. The report of the Smart Specialization Strategy about Information and Communication Technologies shows a medium-high science excellence level in Latvia that can increase the interest to explore exactly what is the advanced analytics level in Latvia. The latest Smart Specialization Strategy of Latvia for 2021-2027 gives some insight about analytics ecosystem and potential support for organizations to develop it [10].

B. Quantitative Survey Design

The primary source has been used to support and provide answers on the research question. The paper draws on quantitative research method. The questionnaire was developed by the author and can be divided into 6 blocks of questions: the default question block with an introduction about the topic of the survey and a metadata browser, the demography block (13 questions), the maturity assessment block (27 questions), the challenges block (4 questions), the solutions block (1 question), and the block about the impact on business (4 questions).

The Author's experience and following sources were used as generators of ideas and the following previous researches were used to design the questionnaire: Rexer analytics survey, McKinsey survey, McKinsey Global Institute research, Global Technology Adoption Survey by Dell, IBM Institute for Business Value research and MIT Sloan research. The most deeply explored and the most of ideas taken from 4 models: Analytics Maturity Quotient Framework (AMQ) [11], DELTA Plus Model [12], Defining analytics maturity indicators (DAMI) [13] and TDWI Analytics maturity model [14]. The questionnaire contains only a few questions that were directly adopted from the previous researches for this survey. Most of the questions and statements are newly created bearing background and ideas from the sources mentioned above.

To ensure an assessment of analytical maturity, 5 domains (Organization, People, Data, Analytics, Technologies.) and 13 factors (Strategy, Process, Human, Sponsorship, Culture, Process, Techniques, Usage, Governance, Quality, Sources, 'Big data' initiatives, Infrastructure) were created basing on 51 statements. The statements were assessed by respondents using a 5-point Likert scale.

The Likert scale was used for the majority of questions to assess the Analytics maturity level. The 5-point scale was used, where 1 means "strongly disagree" and 5 – "strongly agree". The online survey platform Qualtrics was used to build and run the survey. The randomized response method was used with a list of many potential answers provided to ensure reliable results (not influenced by being on the top). The adaptable/ flexible screen solution was used to ensure more reliable answers. An anonymous link was used for distribution of the survey to ensure confidentiality and to be shareable to analytical community by any respondent.

The aim was to collect at least 383 responses to ensure survey result confidence level 95% and margin of error 5%. The Central Statistics Bureau data about number of organizations in Latvia was used to detect minimum required number of respondents to ensure desired confidence level [15].

The Europe Union documentation for the definition of micro, small and medium-sized enterprises was used to define the size of the organization for the purpose of the research [16]-[19].

C. Data Collection

Target group – economically active population taking the role of director, manager, decision maker, owner of the organization in Latvia. The data of this study were obtained using an online survey platform Qualtrics. Majority of respondents were attracted using online panel provider https://intraresearch.com – an invitation to participate in the survey sent. Additional channel was created to attract respondents on homepage http://www.raaconsulting.eu/ with help of Google Ads. For quantitative data processing MS Excel and R software were used. The survey was open from 2021, December 20 to 2022, March 31. At the end, 555 completed questionnaires were received and used for analysis.

The questionnaire form was used consisting of 49 questions. The average length of interview was 28 minutes. Language of survey – Latvian.

To ensure confidentiality regarding specific company (some questions could be interpreted as sensitive), no identification asked, only the business field.

III. Results and Discussion

A. Overall readiness of Latvia's Organizations for Advanced Analytics

The survey was completed by 59% female and 41% male. The aging structure provides answers in 63% of cases in the age group 30-50 and 26% in the age group 51-60 and the rest are over 60 or under the age of 30. 34% of respondents have Master's degree and 32% have a bachelor's degree. Chief executive officers, board members or owners were represented by 16%, directors and Heads of departments by 29% and 41% senior experts with decision making power, the rest of respondents were self-employed, farmers or specialists. All regions of Latvia were represented where Riga and surrounding took 64% and Vidzeme, Latgale, Zemgale, Kurzeme almost equally were covered. All size of organizations were represented almost equally – micro, small, medium and large. All industries based on NACE classification were represented.

A comprehensive block of questions was included in the survey to cover the overall level of advancement of analytics – is it closer to basic analytics or advanced analytics and where exactly it stands. The block includes questions and statements to assess the level of development in specific areas like data, governance, people, culture regarding analytics, tools and techniques used. A 5–point scale was used to find out the respondents' level of agreement/ disagreement with the statements.

The 5 levels were used to describe the readiness for advanced analytics. Beginner (level 1) - with weak analytical capability, only spreadsheet based and issues with data gathering and quality, missing or weak quality data, no support from management. Intermediate (level 2) - silos analytical activities, better data accessibility, autonomous activities, no coordination, no data owners. Specialist (level 3) - wide operational usage with some coordination between analytical community, existing data

warehouses/repositories/data lakes. Expert (level 4) - analytical company with high quality data, integrated analytics in the many processes and decision-making, analytics as competitive advantage. Visionary (level 5) - visionary advanced companies with analytics culture and mindset, testing/adopting cutting edge tools/ techniques/ solutions, highly competitive advantage.

The overall analytics maturity level in Latvia is between 2nd and 3rd stage reaching the 2.4. Fig.1 shows distribution by analytics maturity levels of organizations in Latvia.

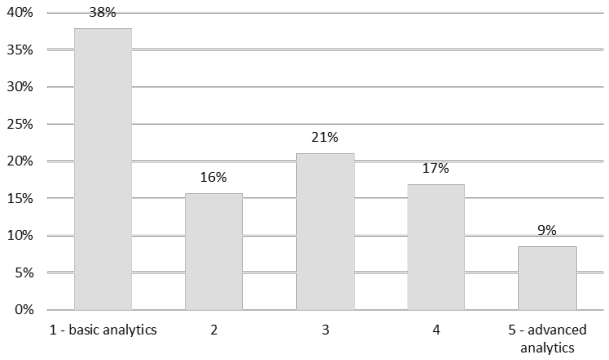

Fig. 1. Advancement level of analytics.

54% of organizations in Latvia are below the level 3rd level what could be translated - quiet weak analytical capability, mostly spreadsheet based, issues with data gathering and quality, no coordinated analytical process, no data owners, weak support from management. However, 26% of organizations could be identified to be in very solid readiness level for advanced analytics - high quality data, integrated analytics in the many processes and decision-making, existing data warehouses/repositories/data lakes, strong analytical culture and mindset, adopting new solutions and technologies, analytics used already as competitive advantage.

Most of organizations do not have Analytics strategy, majority use spreadsheets based analytical tools, half of organizations use mostly only internal data, more than third part of organizations do not have any analytical resources.

B. *Readiness of Latvia's Organizations for Advanced Analytics by segments*

The advancement level of analytics was explored by several segments – regions, organization's size and industry.

Regions

6 regions of Latvia were used for analysis – Riga, surrounding of Riga, Vidzeme, Latgale, Zemgale and Kurzeme according to Latvia's statistical regions and administrative units [20]. The lowest level of advancement of analytics is 2.0 in Kurzeme and Vidzeme, the highest level is in Latgale 2.7, while in Riga analytics advancement level is assessed by 2.6. Standard deviation in a range from 1.2 to 1.5.

Fig.2 shows distribution and analytics maturity level of organizations in Latvia.

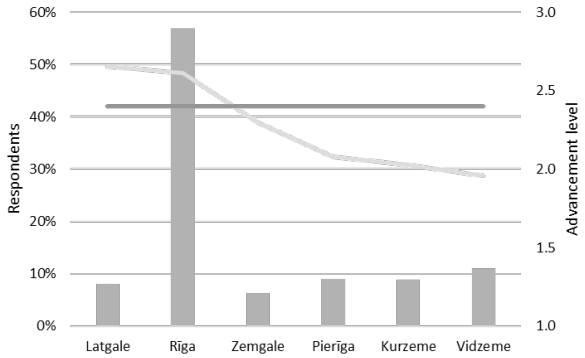

Fig. 2. Advancement level of analytics by regions.

Size

4 segments used to differ organizations by size in Latvia – micro, small, medium and large. The lowest level of advancement of analytics is 1.7 in micro size organizations what means almost basic analytics, the highest level is in large organizations reaching 3.2 what means solid specialist-expert level ensured and are able to use benefits of advanced analytics, while small and medium demonstrates equal level 2.4 which is an average level of analytics maturity of organizations in Latvia. Standard deviation in a range from 1.0 to 1.3.

Fig.3 shows distribution and analytics maturity level of organizations in Latvia.

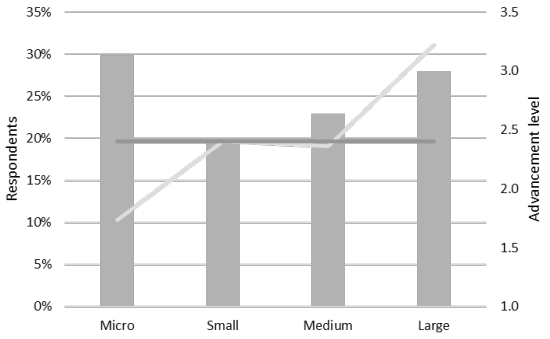

Fig. 3. Advancement level of analytics by size.

Industry

12 segments used to differ organizations by industry in Latvia – based on NACE classification. The lowest level of advancement of analytics is 1.9 in Recreation and art industry, the highest level is in finance industry reaching 3.4. The Information Technologies and Government demonstrates higher than average advancement level of analytics with level of 2.7.

Fig.4 shows distribution and analytics maturity level of organizations in Latvia.

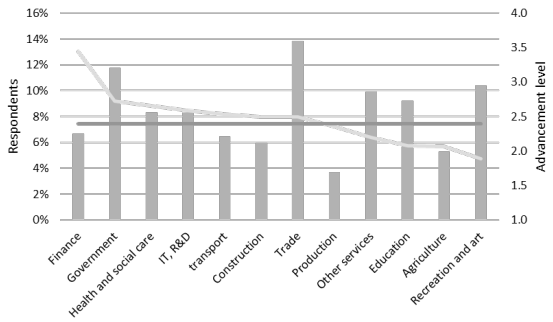

Fig. 4. Advancement level of analytics by industry.

The split by industries demonstrates higher level of analytics in industries where historically operations were based on data and analytics, like Finance. At the same time the lowest level of readiness to adopt advanced analytics is for Education, Agriculture, Recreation and art sectors.

IV. Conclusions

Advanced analytics ecosystem becomes more and more crucial topic in any organization taking into account high digitization demand. Therefore, organization's analytics maturity assessment becomes critical to continue successful business. Thus, the quantitative survey was performed to detect the Readiness of Latvia's Organizations for Advanced Analytics. Such research is not performed in Latvia before.

Ability to assess the analytics maturity level could be attractive to any organization with a drive to use all or most appropriate for specific organization opportunities what is provided by technologies, data and digital solutions. Another reason is a rapid development of technologies, analytical platforms, increase of data volumes, data accessibility for wider audience what puts under the risk competitive advantage.

The survey was run in the beginning of the 2022. Taking into account very fast development of technologies, growing data volumes and more and more user-friendly analytical platforms, it would be required such survey to have annually to monitor readiness of Latvia's organizations for advanced analytics. Any organisation to survive in the digital century should be

The overall level of analytics in Latvia is 2.4 however large organizations, finance industry and partly Information Technologies shows very solid readiness level for advanced analytics even up to 3.4 where majority of required infrastructure and culture in the organization is in place. The one of the lowest level is in Education sector reaching only 2.1 what puts under danger Latvia to become low skilled or not appropriate skilled country for the digital century.

Most of organizations do not have Analytics strategy, majority use spreadsheets based analytical tools, half of organizations use mostly only internal data, more than third part of organizations do not have any analytical resources. It leads to conclusion that majority of Latvia's organizations are far from ability to improve productivity, be able to maximize the potential of the digital environment, to exploit data to make data-driven and automated decisions and are far from 21st century digital opportunities. Thus, puts under danger the sustainability of the organizations itself.

The Baltic region and annual surveys should be conducted to build higher trust ability to this research and the outcomes.

It is possible to run such survey regularly, but what conclusions will be done and what actions will be taken afterwards is even more important topic. Such type survey can be used to develop country level politics, strategies for specific industries or segments. The challenge is to bring organizations who are below specialist level (3) at least to analytics maturity level 3 what allows adopt and implement many advanced analytics features or at least be well-prepared to make next steps to optimize usage of advanced analytics.

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An Review of the Effective Energy Consumption Within the Green IT and Green Energy Strategies

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***Abstract*. The paper provides analysis on the current state of the art in the field of green technologies, including green information technologies, and methods aimed to achieve effective energy consumption goals. Recent advances in the field summarized in prospective publications, were analysed. Modern Green IT and Green Energy strategies, aimed to reduce power consumption, environmental influence and improve sustainability, which assume the use of Cloud Technologies, renewable energy sources, proper recycling and reuse of devices and resources, were singled out. Finally, recommendations for IT and industrial companies aimed helping to achieve green strategies' goals, were formulated.**

Keywords: green IT, cloud computing, green energy, sustainability.

I. INTRODUCTION

The concept of green information technologies (IT) and green energy has become increasingly popular in recent years. Green IT is the practice of using various technologies to reduce energy consumption and increase efficiency within an organization. Green energy is the use of renewable sources such as wind, solar, or geothermal power to generate electricity and reduce reliance on fossil fuels. Both strategies can help organizations save money by reducing their carbon footprint while also increasing sustainability efforts. This paper will analyze the effectiveness of these two strategies in terms of their ability to reduce energy consumption and promote a more sustainable future.

Green IT strategies focus on reducing the amount of energy consumed by technology systems through improved design and efficient usage practices. These methods include virtualization, cloud computing, and the use of more efficient hardware. Virtualization is a process by which multiple virtual machines are created on one physical server, reducing the amount of energy needed to power them. Cloud computing allows for data and applications to be hosted in a remote location, eliminating the need for local servers that consume energy. Finally, using more efficient hardware such as LED monitors or low-power processors can help reduce energy consumption.

Green energy strategies focus on increasing the use of renewable sources to generate electricity instead of relying solely on fossil fuels. These methods include solar panels, wind turbines, geothermal plants and hydroelectric dams. Solar panels convert sunlight into electricity while wind turbines generate electricity from the motion of air currents. Geothermal plants use the heat from underground sources to generate electricity and hydroelectric dams utilize the power of moving water. These methods are more sustainable than traditional energy sources, as they do not produce greenhouse gas emissions or require fossil fuels to operate.

Both green IT and green energy strategies can be effective in reducing energy consumption and promoting sustainability efforts. Green IT strategies focus on improving efficiency within an organization by using virtualization, cloud computing, and efficient hardware. This reduces the amount of energy needed to power

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technology systems while also increasing productivity levels. On the other hand, green energy strategies focus on increasing the use of renewable sources such as solar panels, wind turbines, geothermal plants and hydroelectric dams instead of relying solely on fossil fuels for electricity. This reduces the amount of greenhouse gas emissions released into the atmosphere while also providing a more sustainable energy source.

II. Materials and Methods

The issue of the rational use of natural resources became topical during last decades. Since then, number of standards and regulations were established in different countries and by different international organizations to make production process 'greener' and decrease overall energy consumption. Thus, in [1] authors present an integrated framework for 'greening' the enterprise based on ISO 14001 standard requirements. The authors argue that this framework can be used as a tool to identify and address environmental issues, increase corporate sustainability, and reduce costs associated with compliance. The paper also outlines how this framework can help organizations in their transition to sustainable operations by providing guidance on selecting appropriate measures, implementing them effectively, and monitoring results. The paper provides a comprehensive overview of the key elements of ISO 14001 certification requirements and discusses how they contribute to 'greening' the enterprise. It examines various approaches such as environmental management systems (EMS), pollution prevention/minimization strategies, energy efficiency initiatives, waste reduction efforts and other areas related to resource conservation. Additionally, it highlights some case studies which demonstrate successful implementation of these strategies at different types of organizations ranging from manufacturing companies to government offices. Overall in [1] authors offer an insightful look into how organizations can benefit from adopting an integrated approach towards achieving sustainable operations through ISO 14001 standards-based frameworks. The authors provide useful information about best practices for developing such frameworks that could prove beneficial for businesses looking to make their operations more environmentally friendly while reducing compliance costs in the process.

Information technologies, as well as proper production and use of IT equipment, could make significant contribution into Green Energy strategies as well. In [2] authors provide an overview of Green IT and its potential to reduce carbon emissions from information systems. The authors discuss the challenges associated with implementing Green IT, such as the need for a comprehensive understanding of system architecture and energy consumption patterns, as well as the difficulty in measuring actual reductions. They also provide several strategies for reducing carbon emissions through Green IT initiatives, including increasing energy efficiency, optimizing resource utilization, and utilizing renewable energy sources. Finally, they suggest that organizations should develop long-term plans for implementing these strategies over time to maximize their effectiveness. Overall, this paper offers an insightful look into how organizations can use Green IT practices to reduce their environmental impact while still meeting their business objectives.

Similar suggestions are presented in [3]. Authors provide an analysis of green ICT initiatives as a strategic approach towards sustainable development. The authors examine the potential for green technology to reduce environmental impacts, improve energy efficiency and create new economic opportunities. They discuss how governments, corporations and individuals can all play a role in advancing green ICT solutions through regulatory frameworks, public-private partnerships and consumer behaviour changes. They also consider the importance of taking a holistic view of sustainability that considers both economic growth and environmental protection when developing policies related to green ICTs. Overall, this paper provides a comprehensive overview of the current state of green ICT initiatives, their potential benefits and implications for policy makers looking to promote sustainable development through these technologies.

In [4] it was presented an overview of the concept of "Green IT" and its importance for sustainable development. The paper argues that Green IT is a strategic approach to sustainability, as it involves the implementation of technologies and practices that reduce the environmental impact of computing systems while improving their efficiency. The authors discuss various approaches such as energy-efficient hardware design, software optimization techniques, virtualization, cloud services, and green data centers. They also provide examples of how organizations can use these methods to reduce their carbon footprints and save money in the process. Finally, they conclude by emphasizing that Green IT should be seen as an integral part of corporate strategy for achieving long-term sustainability goals. Overall this paper provides a comprehensive look at how organizations can use Green IT strategies to improve their environmental performance while reducing costs associated with infrastructure operations. It serves as a useful resource for those interested in learning more about this topic and making informed decisions on how best to implement such initiatives within their own organization or industry sector.

Best green practices, adopted in information technologies, also could be adopted by organizations of a different type. Thus, in [5] authors present research exploring the potential for organizations to reduce their carbon emissions through the implementation of green information technology practices. The authors provide an in-depth analysis of existing literature and propose several strategies for reducing organizational carbon emissions. They identify four key areas where green IT can be used: energy efficiency, virtualization, eco-friendly applications, and recycling/reuse initiatives. In addition, they provide detailed recommendations on how each area can be implemented within an organization's operations. Overall, this paper provides valuable insight into how organizations can use green information technology

practices to reduce their environmental impact by reducing carbon emissions. It is comprehensive in its approach and offers practical advice that could be applied in real-world settings with relative ease. This makes it a useful resource for organizations looking to reduce their carbon footprint while also improving operational efficiency and productivity levels.

Even if cloud technologies and big data centers are used for more effective energy usage, they still remain one of the biggest energy consumers in the world. So, a number of researches are devoted to the question of their energy consumption reduction.

An extensive review of green IT and green energy strategies for effective energy consumption in data centers is given in [6]. The authors identify various strategies, such as the use of virtualization technologies, improved cooling systems, efficient power supplies, and renewable energy sources. They also discuss the importance of metrics such as Power Usage Effectiveness (PUE), Carbon Usage Efficiency (CUE), and Data Center Infrastructure Efficiency (DCIE). The authors conclude that while there are many potential benefits to implementing these strategies in data centers, further research is needed to optimize their effectiveness. Overall, this paper provides a comprehensive overview of current approaches to reducing energy consumption in data centers. It highlights the need for further research into optimizing existing practices and exploring new methods for managing resources more efficiently. Given the growing demand for computing power worldwide, it is essential that organizations consider how they can improve their sustainability efforts through green IT initiatives

Paper [7] examines the role of green IT strategies in data centers and their effectiveness in utilizing energy resources. The authors conducted a systematic literature review to assess the current state of research on this subject, finding that while some studies have been done, there is still much unknown about these technologies. They conclude that more research is needed to fully understand how green IT strategies can be best utilized in data centers for maximum efficiency and cost savings. Overall, this paper provides an important foundation for further exploration into the field of green IT strategies and their potential benefits for data center operations.

Another paper related to this question represents a survey of green IT and green energy strategies for reducing the electricity consumption in data centers [8]. The authors provide an overview of existing technologies such as virtualization, cloud computing, renewable energy sources such as solar and wind power, energy efficiency measures such as cooling systems and efficient lighting solutions. They also discuss the challenges faced by organizations when implementing these technologies. In addition to this analysis, they propose several recommendations for improving the overall efficiency of data centers through better management practices and improved infrastructure design. Overall, this paper provides a comprehensive review of current green IT and green energy strategies used to reduce electricity consumption in data centers. It offers a valuable insight into how organizations can improve their operations while simultaneously achieving cost savings through improved sustainability initiatives. Furthermore, it highlights some potential areas where further research could be conducted to further optimize the use of technology within these environments.

As the power management plays crucial role ensuring overall effectiveness of the datacentre power consumption, related research results are presented in [9]. In this paper authors investigate the potential of Green IT/energy management strategy for improving power efficiency in cloud computing. This paper is a comprehensive review of existing green energy strategies that can be employed to reduce energy consumption and improve power efficiency in cloud computing environments. The authors focus on four key areas: data centers, virtualization, server consolidation, and workload optimization. They also discuss various techniques such as dynamic resource scheduling, CPU throttling algorithms, and intelligent cooling systems which can be used to reduce energy consumption while maintaining system performance. The findings of this paper are significant because they demonstrate how organizations can use green IT/energy management strategies to significantly improve the power efficiency of their cloud computing infrastructure while reducing costs associated with high levels of electricity usage. Additionally, these strategies have been shown to result in improved environmental sustainability by decreasing carbon emissions from data centers. Overall, this paper provides a valuable insight into effective ways for companies to optimize their cloud computing environment without sacrificing performance or incurring additional costs related to excessive electricity usage.

In particular, studies [10–13] authors revealed the potential opportunities and risks of implementing ICT as a tool and driver of smart transformations according to the traditional (high-carbon) and "green" (low-carbon) scenarios of global economics evolution in general. Analytical reviews [14, 15] summarize strategic initiatives to improve environmental performance, combat global warming, and improve resource management by means of the ICT industry. Methodical approaches for assessing the social and ecological and economic efficiency of ICT implementation at different stages of the product life cycle were developed in [16–18]. Determination of “green” ICT implementation in organizations, as well as the terminology, are given in [19].

Provided analysis allowed us to single out pros and cons for green IT and green energy strategies implementations, summarized in table 1.

TABLE 1 PROS AND CONS FOR GREEN STRATEGIES IMPLEMENTATION

Pros	***Cons***
Green IT strategies implementation	
Reduced costs - Companies can save money on energy bills, water and other resources by implementing green IT strategies.	High initial investment - Green technology often requires high upfront costs in order to purchase equipment or software needed for implementation which may not be feasible for all businesses depending on size or budget constraints.
Increased efficiency - By utilizing green IT solutions, companies can increase the performance of their systems while reducing resource consumption and waste production	Technical complexity – The implementation of new technologies such as cloud computing or virtualization require technical expertise which many small businesses lack making it difficult for them to adopt these technologies without outside help from consultants or vendors who charge additional fees for services rendered.
Improved public image - Implementing green IT practices can project a positive image to customers, shareholders and the general public that a company is committed to sustainability and environmental protection.	Limited resources – Many organizations do not have access to adequate resources such as skilled staff members with knowledge about green IT solutions which make it hard for them to implement these strategies successfully within their own organization.
Enhanced employee morale - Knowing that their work contributes to the environment may lead employees to be more productive as they feel proud of working for an environmentally conscious organization.	Regulatory uncertainty – The lack of clear and consistent regulations on sustainable practices makes it difficult for companies to know what is expected from them in order to be compliant with the law.
Green Energy strategies implementation	
Reduces the company's carbon footprint and helps to protect the environment.	The initial cost of setting up a green energy system may be high, depending on what type of technology is used and how much infrastructure needs to be built or upgraded.
Can save on energy costs, as green energy sources are often cheaper than traditional sources of power.	Some types of renewable technologies may not be available in certain areas due to lack of resources or other factors
May qualify for government incentives such as tax credits or grants that can offset some of the upfront costs associated with implementing a green energy strategy.	Green energy systems require ongoing maintenance and monitoring which can add additional costs over time
It can be used to attract new customers who are interested in supporting environmentally friendly companies	It can be difficult to measure the impact of green energy initiatives on a company's bottom line

So, we can conclude, that Green IT plays extremely important role in achieving environment-friendly society, which helps in achieving sustainability goals. A number of approaches aimed to either use IT to increase efficiency of energy use in production and industry, or implement energy saving approaches within IT itself, are analysed, and recommendations based on provided analysis are presented in the next section.

III. RESULTS AND DISCUSSION

As it follows from provided analysis, Green IT and Green Energy strategies are two important tools that organizations can use to reduce their energy consumption. By using these strategies, organizations can achieve significant cost savings, reduce their environmental impact, and improve the efficiency of their operations. This analysis helps to explore the effective energy consumption within each strategy and how they can be used together to maximize savings. Green IT is a set of practices designed to optimize IT systems for improved performance while reducing energy usage. It involves implementing technologies such as virtualization, cloud computing, server consolidation, and efficient power management techniques in order to maximize resource utilization while minimizing waste.

The primary goal of Green IT is to reduce the amount of electricity consumed by an organization's IT infrastructure so that it uses less resources overall. Studies have shown that up to 75% of an organization's total electricity bill may be attributed directly or indirectly to its IT equipment alone – making it essential for any business looking to save money on its utility bills. Green IT methods are practices and technologies that reduce the environmental impact of information technology. Examples include using energy-efficient hardware, virtualizing servers, optimizing data center cooling systems, utilizing cloud computing services to reduce server power consumption, recycling old computers and electronics responsibly, monitoring air quality in the office environment, and implementing energy efficient lighting solutions.

Green Energy strategies involve utilizing renewable sources such as solar or wind power instead of traditional fossil fuels like coal or natural gas in order to generate electricity more efficiently and with fewer emissions than conventional methods do. Renewable energy sources also provide greater reliability since they do not rely on finite fuel reserves like oil or gas does; this makes them inherently more sustainable over time as well as cheaper in terms of long-term costs associated with fluctuating prices for traditional fuels.

Additionally, investing in green energy projects has been demonstrated both economically beneficial due to government incentives provided for doing so; consequently, many businesses now view green investments from a financial perspective rather than just from an environmental one – leading some large companies even go beyond simple compliance measures towards carbon neutrality goals altogether. When combined properly Green IT and Green Energy strategies create a powerful synergy which greatly reduces an

organization's overall electricity usage – allowing them take advantage both cost savings through reduced bills but also increased sustainability via lower emissions output compared against non-green options available elsewhere otherwise. When implemented correctly these approaches should result in substantial reductions both immediate operational expenses incurred during day-to-day operations plus future maintenance costs associated with replacing outdated hardware/software after useful life period expires without having invest heavily into new replacements every few years too frequently either way – allowing companies focus other initiatives more effectively.

The cost of implementing a green energy strategy in a small company will vary depending on the size and scope of the project. Typically, costs range from $500 to several thousand dollars for an audit and assessment, plus the cost of any equipment or materials needed to implement green energy strategies. In addition, there may be additional costs associated with training staff and educating customers.

The cost of implementing a green energy strategy in a middle size company can vary greatly depending on the type of green energy technology being implemented, the size of the company, and any incentives available from local or federal government programs. Generally speaking, however, it is estimated that installing solar panels to generate electricity can start at around $10-15k for an average sized business. Other technologies such as wind turbines or geothermal systems may cost more upfront but have lower operating costs over time.

In any case, under modern conditions, it is reasonable implement Green IT and Green Energy strategies for companies. Although it may require some upfront investment and resources, implementing these strategies can help the company save money on energy costs in the long run and also reduce its environmental impact. Additionally, many governments provide tax incentives or subsidies for companies that invest in green technology, so this could be an added financial benefit as well.

If we take a look at a state level, we could conclude, that Latvia is a country that has seen dramatic changes in its energy efficiency and usage over the years. With the implementation of green strategies, it has become one of the leading countries in Europe in energy generation from renewable resources, after Sweden, Finland and Denmark [20]. Following we describe how Latvia's effective energy consumption has been impacted by these green strategies and what can be done to further improve of their effectiveness.

One key factor that affects Latvia's effective energy consumption is its commitment to renewable sources of energy. In recent years, Latvia has significantly increased its investments into renewable sources such as hydropower and biomass generation, which in 2016 accounted for more than 56% of total electricity production [21].

Additionally, with government support through subsidies and incentives, green initiatives have become increasingly popular among businesses in the country, leading to an even bigger focus on sustainability across all sectors. In addition to focusing on renewable resources for power generation, Latvia also focuses on reducing overall demand for electricity by promoting greater efficiency throughout households and industry alike. The Latvian government offers various schemes aimed at improving building insulation standards or encouraging businesses to undertake retrofitting projects; this helps reduce both direct emissions from heating/cooling systems as well as indirect emissions resulting from reduced reliance on imported fossil fuels. Moreover, since 2019 all new buildings must comply with stringent EU-wide standard regulations regarding minimum energy performance requirements before they can receive any form of construction permit approval; this ensures efficient use of resources within newly constructed structures while also ensuring compliance with international laws related to carbon footprint reduction targets set out by European Union member states. Finally increasing public awareness about climate change and implementing policies geared towards reducing waste are additional ways through which Latvia could further reduce its environmental impact moving forward. Through campaigns which encourages people living near coastal areas not only clean up but also prevent litter pollution, or via incentives for switching regular lightbulbs with LED ones, Latvian citizens would be able to make meaningful contributions towards decreasing their own carbon footprints. Overall, it can be concluded that through continued investment into renewable technologies combined with promotion of efficient design principles coupled with public education and prevention programs, Latvia is well positioned continue making advances when it comes efficient utilization and management of natural resources as well as creating a cleaner environment in the future.

Green IT in Latvia is aimed at reducing the amount of energy and resources used by IT systems. This includes initiatives to increase energy efficiency, reduce data center emissions, promote green computing practices, and develop sustainable digital infrastructure. Efforts are also being made to improve access to e-services for Latvian citizens with the goal of increasing ICT sustainability across the country. The government has established a National Green Information Technology Program which provides funding for projects that focus on improving environmental awareness among businesses and individuals. Additionally, there have been several conferences held in Latvia focusing on green IT topics such as cloud computing and virtualization technologies.

Summarizing provided research results, we can conclude, that to achieve Green IT goals, we should suggest following recommendations:

– implement energy-saving technologies: adopting energy-efficient technologies such as LED lighting, motion sensors and automated temperature control systems which can help reduce power consumption in the IT environment;

– reduce paper use: reducing the amount of paper used throughout organization is an easy way to make a green impact; utilize digital document management solutions and encourage staff to print double-sided documents when necessary (for example, for documents such as reports, presentations, brochures, manuals and booklets. It can also be used for printing out emails or webpages that have a lot of content.);

– update hardware regularly: consider upgrading outdated computer hardware that is no longer efficient or reliable on a regular basis with more energy efficient models; this will reduce electricity consumption significantly over time and improve performance at the same time;

– virtualize data centers: cloud services provide organizations with access to powerful computing resources while eliminating the need for expensive physical hardware setups, thus reducing electricity costs and freeing up valuable office space as well;

– recycle old equipment responsibly: when disposing of old computers or other IT equipment, be sure to properly recycle them in accordance with local laws and regulations – preventing hazardous materials from entering landfills is crucial for maintaining a healthy planet.

IV. Conclusion

In conclusion, we may state that green IT and green energy strategies can be effective in reducing energy consumption and promoting sustainability efforts. Green IT focuses on improving efficiency within an organization by using virtualization, cloud computing, and efficient hardware while green energy focuses on increasing the use of renewable sources such as solar panels, wind turbines, geothermal plants and hydroelectric dams instead of relying solely on fossil fuels for electricity. Both strategies can help organizations save money by reducing their carbon footprint while also increasing sustainability efforts. Nowadays governments and international organizations promote green IT and green energy strategies, and support organizations and individuals following such strategies. Thus, meeting sustainable environmental goals, besides its original idea to protect environment, could also be beneficial to organisations and individuals from financial point of view.

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Factor Analysis of Web-based Idea Management System Application Results

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Abstract. **The aim of the study is to reveal the underlying factors from variable data collected on the results of the web-based ideas management systems related to management and tangible results in companies. The purpose of the factor analysis process is to collect the information contained in a large number of changes in such a way as to obtain latent factors with minimal data loss. Authors have conducted global survey for enterprises that apply these systems (n>500). The 8 variables that fit together reveal the latent factor "tangible" or tangible results and the remaining 6 variables that together reveal the latent factor "managerial" or the management results.**

Keywords: Idea Management Systems, Web-based, Factor Analysis, Results.

I. INTRODUCTION

Open innovations help organizations manage knowledge across boundaries as inflows and outflows [1], [2] of knowledge, and they are becoming an important part of the innovation ecosystem [3]-[5]. On the one hand, the growing popularity of open innovations, and on the other hand, the digitalization and distance work (especially during COVID-19) are leading organizations to the application of different virtual tools that help manage innovation ecosystems and open innovations."

Web-based idea management systems (IMS) are software applications that allow individuals or groups to submit, track, and manage ideas. The paper discusses the assumption that an IMS is a tool that provides idea management. Idea management is a systematic and manageable process of idea generation, evaluation, and repeated idea generation and evaluation if needed [6], [7]. These tools can be used for a variety of purposes, such as product development, problem solving, or marketing. There are many different web-based IMS available, and each has its own strengths and weaknesses. It is important to conduct a factor analysis of web-based IMS applications to determine which system is best suited for a company's needs. Overall, web-based IMS offer a number of benefits, including increased productivity, improved communication, easier collaboration, and greater creativity.

Web-based IMS are becoming increasingly popular for several reasons:

- Increased accessibility: Web-based IMS can be accessed from anywhere with an internet connection, making it easy for employees to submit, track, and manage ideas, regardless of location.
- Improved communication and collaboration: Web-based IMS allow for real-time communication and collaboration among team members, which can help to improve the quality and quantity of ideas generated.
- Increased productivity: Web-based IMS can automate and streamline the idea generation and management process, leading to increased productivity.
- Greater flexibility: Web-based IMS offer more flexibility than traditional, paper-based systems and can be easily customized to meet the specific needs of an organization.
- Cost-effective: Web-based IMS are typically less expensive to implement and maintain than traditional, on-premises systems.
- Data analytics capabilities: Web-based IMS can track and analyze ideas, providing valuable insights that can

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be used to improve the organization's processes and decision-making.

- Shift to remote work: Due to the COVID-19 pandemic, many organizations have shifted to remote work, and web-based IMS provide an easy way for employees to collaborate and share ideas when working from different locations.

Study problem: There is currently a large amount of variable data collected on the impact of the IMS on management and tangible results. It is not easy to interpret and use this data without further data processing.

Purpose of the study: Using research analysis to identify the relationship between large-scale variables and to obtain a reduced number of variables that will help to explain and interpret the results of the survey.

Main contribution: The purpose of the study is to identify the underlying factors that affect the success of web-based IMS in companies. The study will also explore the relationship between management and tangible results in companies that use these systems.

II. Materials and Methods

The study conducted a survey to obtain primary data on the use and results of web-based IMS among companies. The survey was conducted on the "QuestBack" platform set up by UNIPARK, which was chosen for its focus on academic surveys, its widespread use among world-class researchers, its data security, and its compliance with the EU General Data Protection Regulation. To reach the survey audience more precisely, 107 IMS representatives were asked to distribute it to their customers, only to companies that were currently using the system and the person responsible for IMS. The authors, through private communication with 107 IMS developers, estimated that IMS is used by around 120,000 companies. In total, the responses of 400 enterprises with web-based IMS experience were included in the analysis.

For analysis, the authors used a dataset gathered with a global enterprise survey (n>500) conducted in Q4 of 2022, on the topic of applying web-based IMS and their results in companies.

Number of observations: 505. Based on Tabachnick and Fidell [8], the number of 500+ observations is considered to be very good. Together, the analysis will include 14 variables, which means that there are approximately 35 observations per variable.

Variable data was collected using a survey based on a 7-point Likert Scale, where 1 represents "I certainly do not agree" (Strongly Disagree) and 7 represents "I certainly agree" (Strongly Agree). All variables correspond to the objective of the survey section to respond as the results of the web-based IMS relate to management and statistical results within the company.

The following data from a previously conducted survey on the use of web-based IMS is available for the current study.

The variable data was obtained by asking the following question: "Using the scale below, indicate to what extent each of the following items pertain to the outcomes of the web-based IMS related to management and tangible results in your enterprise."

The data were collected on the following variables, which were selected based on the literature review. See variables in Table 1.

TABLE 1 VARIABLES

Idea management system application has …
… Stimulated growth - turnover
… Improved customer satisfaction
… Improved quality
… resulted in income increase
… resulted in cost reduction
… resulted in growth of the market share
… Improved productivity
… resulted in growth of the number of new products
… Improved decision making
… helped to achieve goals
… Improved information management
… Improved overall management effectiveness
… helped to set the goals
… Improved ability to respond to change

Sources: created by the authors

The study utilizes factor analysis, a statistical technique, to identify the key factors that contribute to the variability in the results of a survey on the usage and outcomes of web-based IMS in companies. The factors are the underlying variables that explain the observed variability in the survey data. The goal of the analysis is to determine which variables, and to what extent, these variables jointly produce latent factors that explain the variability in the results of the survey. All variables in the sample align with this assumption, as they are based on latent factors that are measured.

III. Results and Discussion

The factor analysis begins by examining the correlation matrix. Based on the correlation matrix, all variables used for the factor analysis have a correlation with one another (see in Table 2).

TABLE 2 CORRELATION MATRIX

Code	Variable	v_101_q_5622770	v_94_q_5622770	v_95_q_5622770	v_96_q_5622770	v_98_q_5622770	v_99_q_5622770	v_100_q_5622770	v_193_q_5622770	v_103_q_5622770	v_133_q_5622770	v_134_q_5622770	v_135_q_5622770	v_136_q_5622770	v_102_q_5622770
v_101_q_5622770	Idea management system application has helped to achieve goals	1.000													
v_94_q_5622770	Idea management system application has improved decision making	0.838	1.000												
v_95_q_5622770	Idea management system application has improved productivity	0.492	0.510	1.000											
v_96_q_5622770	Idea management system application has improved information management	0.744	0.773	0.554	1.000										
v_98_q_5622770	Idea management system application has improved overall management effectiveness	0.680	0.726	0.532	0.716	1.000									
v_99_q_5622770	Idea management system application has improved quality	0.370	0.385	0.729	0.451	0.406	1.000								
v_100_q_5622770	Idea management system application has resulted in cost reduction	0.556	0.572	0.714	0.585	0.555	0.750	1.000							
v_193_q_5622770	Idea management system application has resulted in income increase	0.524	0.544	0.693	0.571	0.533	0.719	0.851	1.000						
v_103_q_5622770	Idea management system application has stimulated growth - turnover	0.482	0.516	0.684	0.535	0.488	0.707	0.816	0.822	1.000					
v_133_q_5622770	Idea management system application has improved costumer satisfaction	0.510	0.510	0.676	0.545	0.509	0.704	0.803	0.812	0.823	1.000				
v_134_q_5622770	Idea management system application has resulted in growth of the market share	0.530	0.525	0.679	0.546	0.517	0.692	0.810	0.796	0.802	0.835	1.000			
v_135_q_5622770	Idea management system application has resulted in growth of the number of new products	0.617	0.628	0.595	0.642	0.595	0.616	0.730	0.752	0.701	0.743	0.773	1.000		
v_136_q_5622770	Idea management system application has helped to set the goals	0.660	0.660	0.576	0.658	0.664	0.534	0.704	0.698	0.609	0.663	0.708	0.782	1.000	
v_102_q_5622770	Idea management system application has improved ability to respond to change	0.634	0.632	0.543	0.630	0.600	0.490	0.669	0.661	0.665	0.669	0.698	0.740	0.774	1.000
v_101_q_5622770	Idea management system application has helped to achieve goals														
v_94_q_5622770	Idea management system application has improved decision making	0.000													
v_95_q_5622770	Idea management system application has improved productivity	0.000	0.000												
v_96_q_5622770	Idea management system application has improved information management	0.000	0.000	0.000											
v_98_q_5622770	Idea management system application has improved overall management effectiveness	0.000	0.000	0.000	0.000										
v_99_q_5622770	Idea management system application has improved quality	0.000	0.000	0.000	0.000	0.000									
v_100_q_5622770	Idea management system application has resulted in cost reduction	0.000	0.000	0.000	0.000	0.000	0.000								
v_193_q_5622770	Idea management system application has resulted in income increase	0.000	0.000	0.000	0.000	0.000	0.000	0.000							
v_103_q_5622770	Idea management system application has stimulated growth - turnover	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
v_133_q_5622770	Idea management system application has improved costumer satisfaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000					
v_134_q_5622770	Idea management system application has resulted in growth of the market share	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
v_135_q_5622770	Idea management system application has resulted in growth of the number of new products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
v_136_q_5622770	Idea management system application has helped to set the goals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
v_102_q_5622770	Idea management system application has improved ability to respond to change	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Sources: created by the author

Importantly, as this survey measures both tangible and management results through web-based IMS it is possible that both tangible and management results are positively affected by these systems. Therefore, the correlation between all variables is expected and the latent factors themselves may also be correlated. The analysis of the factors will continue using this data. The first factor analysis test is a validity test used to confirm the extent to which measurements effectively measured the true significance of each structure to which the measurement belongs [9], [10]. When investigating the design's validity, it may be used to further reduce the total observed number of non-adequate variables. At first, each design was tested using the Kaiser-Meyer-Olkin (KMO) test and the Barlett spherical test. KMO is a measure used to determine the conformity of sampling or whether the sample size is large enough to be used for further factor analysis [10]. The Barlett spherical test is used as an indicator of the strength of the ratio of different measurements [10]. The match measure for the sample of KMO is 0.958 with a significant Barletta spherical test (Sig. $P < 0.05$). These values indicate that the data are sufficient to be used for further factor analysis [10], [11]. All variables can be used for factor analysis. See in Table 3.

TABLE 3 KMO AND BARTETT'S TEST

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,958
Bartlett's Test of Sphericity	Approx. Chi-Square	7369,826
	DF	91
	Sig.	0,000

Sources: created by the authors

In addition, the use of Anti-image correlation and Measures of Sampling Adequacy (MSA) determines that all variables have a MSA value above 0.9. All variables can be included in the factor analysis. The selection of the number of factors will be based on the principal component analysis by which eigenvalue and scree plots are obtained. Based on this analysis, 2 components have an eigenvalue above 1.0 which indicates that none of the components has negative credibility. Overall, these 2 components explain the dispersion of 77.68%. See in Table 4.

TABLE 4 TOTAL VARIANCE EXPLAINED

Component	**Initial Eigenvalues**			**Extraction Sum of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%
1	9,389	67,061	67,061	9,389	67,061	67,061	6,166	44,041	44,041
2	1,512	10,801	77,862	1,512	10,801	77,862	4,735	33,822	77,862
3	0,604	4,313	82,175						
4	0,378	2,698	84,873						
5	0,319	2,278	87,151						
6	0,291	2,076	89,227						
7	0,263	1,878	91,105						
8	0,239	1,709	92,814						
9	0,222	1,586	94,400						
10	0,194	1,386	95,786						
11	0,163	1,167	96,953						
12	0,154	1,101	98,055						
13	0,140	1,002	99,057						
14	0,132	0,943	100,000						
Extraction Method: Principal Component Analysis.									

Sources: created by the authors

The study used VARIMAX with Kaiser normalization as the rotation method to produce the results. This method was chosen because it minimizes the number of variables with large weights that match the factor. The study identified (latent) 2 factors after 3 rotations. The highlighted factors have a pronounced compatibility together, as shown in Table 5.

TABLE 5 ROTATED COMPONENT MATRIX

	Component	
Variable Idea management system application has …	1	2
… stimulated growth - turnover	0,853	0,302
… improved quality	0,847	
… resulted in income increase	0,840	0,362
… resulted in cost reduction	0,834	0,387
… resulted in growth of the market share	0,833	0,362
… Improved productivity	0,733	0,344
… resulted in growth of the number of new products	0,668	0,556
… improved decision making		0,882
… helped to achieve goals		0,870
… Improved information management	0,328	0,817
… Improved overall management effectiveness		0,801
… helped to set the goals	0,550	0,664
… Improved ability to respond to change	0,551	0,624

Sources: created by the authors

The extracted components have a correlation above above 0.65, with the majority between 0.7 and 0.8. The relationship is of sufficient importance to be kept in the factor analysis (see highlighted parts in Table 6).

TABLE 6 COMMUNALITIES

Variable Idea management system application has …	**Initial**	**Extraction**
… helped to achieve goals	1,000	0,817
… Improved decision making	1,000	0,844
… Improved productivity	1,000	0,656
… Improved information management	1,000	0,775
… Improved overall management effectiveness	1,000	0,726
… Improved quality	1,000	0,741
… resulted in cost reduction	1,000	0,845
… resulted in income increase	1,000	0,836
… Stimulated growth - turnover	1,000	0,818
… Improved costumer satisfaction	1,000	0,827
… resulted in growth of the market share	1,000	0,825
… resulted in growth of the number of new products	1,000	0,756
… helped to set the goals	1,000	0,743
… Improved ability to respond to change	1,000	0,693

Sources: created by the authors

Both 2 extracted component factor loads are greater than 0.5, which exceeds sufficient factor load, and together with 2 extracted components explain 77.86% of the variation [10]. It shows that the 2 extracted components are well-suited. See in Table 7.

TABLE 7 TOTAL VARIANCE EXPLAINED

Component	Initial Eigenvalues			Extraction Sum of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%
1	9,389	67,061	67,061	9,389	67,061	67,061	6,166	44,041	44,041
2	1,512	10,801	77,862	1,512	10,801	77,862	4,735	33,822	77,862
3	0,604	4,313	82,175						
4	0,378	2,698	84,873						
5	0,319	2,278	87,151						
6	0,291	2,076	89,227						
7	0,263	1,878	91,105						
8	0,239	1,709	92,814						
9	0,222	1,586	94,400						
10	0,194	1,386	95,786						
11	0,163	1,167	96,953						
12	0,154	1,101	98,055						
13	0,140	1,002	99,057						
14	0,132	0,943	100,000						
Extraction Method: Principal Component Analysis.									

Sources: created by the authors

The highlighted factors must be interpreted. The 8 variables that fit together reveal the latent factor "tangible" or tangible results and the remaining 6 variables that together reveal the latent factor "managerial" or the management results. See in Table 8.

The results match the expected outcomes. The survey questions that resulted in the variables were based on the inclusion of two types of web-based IMS on results, specifically management and tangible results. When examining variables grouped only in each structure, they correspond to the purpose of the question on which they were designed. The aim of the analysis has been achieved by identifying the underlying factors through factor analysis. It is also likely that all variables are correlated with each other, and that the two identified factors are also correlated with each other. This is expected, as the use of web-based IMS would likely have a similar impact on both tangible and management results in practice.

TABLE 8 HIGLIGTED FACTOTS

Variable - Idea management system application has …	
… Stimulated growth - turnover	**1 Tangible outcome**
… Improved costumer satisfaction	
… Improved quality	
… resulted in income increase	
… resulted in cost reduction	
… resulted in growth of the market share	
… Improved productivity	
… resulted in growth of the number of new products	
… Improved decision making	**2 Management results (Managerial outcome)**
… helped to achieve goals	
… Improved information management	
… Improved overall management effectiveness	
… helped to set the goals	
… Improved ability to respond to change	

Sources: created by the authors

The confidence test shall be used to confirm whether the values measured in the design are internally consistent and reflect the same design. For this purpose, Cronbach Alpha is used, which measures the degree to which the items measured in the design are of the same or similar type or nature to be used in the design [10]. Cronbach Alpha is often used as an indicator to test the reliability of the aggregated rating scales [12]. The value of Cronbach Alpha can be any value from 0 to 1, and according to Cronbach [13] the value must be at least 0,7 or more for the measurement to be reliable. However, there is evidence that Cronbach Alpha value of 0.6 or higher remains a good indicator of internal consistency [10], [11].

In addition to the use of Cronbach Alpha to measure reliability, the adjusted total correlation of items is also considered to check whether a measurement in the design is not consistent and should therefore be removed from the structure. According to J. Glus [14], if the adjusted total of units is less than 0,4, the variables should be excluded from the analysis. In the conclusions, both structures have a value of Cronbach Alpha of 0.7 or higher. See in Table 9.

TABLE 9 RELIABILITY STATISTICS

	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
1	0,959	0,959	8
2	0,927	0,931	6

Sources: created by the authors

The adjusted unit total for correlation is also above 0.7. Both results lead to the conclusion that variables contained in constructions are internally consistent and reflective of the same design that is measured. See in Table 10.

TABLE 10 ITEM-TOTAL STATISTICS

Variable	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Idea management system application has improved productivity	33.19	83.973	0.762	0.615	0.958
Idea management system application has improved quality	33.26	82.806	0.788	0.656	0.956
Idea management system application has resulted in cost reduction	33.05	80.595	0.892	0.806	0.950
Idea management system application has resulted in income increase	33.09	79.522	0.886	0.803	0.951
Idea management system application has stimulated growth - turnover	33.14	78.944	0.870	0.775	0.952
Idea management system application has improved costumer satisfaction	33.13	79.458	0.879	0.790	0.951
Idea management system application has resulted in growth of the market share	33.09	78.156	0.876	0.788	0.951
Idea management system application has resulted in growth of the number of new products	32.78	83.640	0.790	0.658	0.956
Idea management system application has helped to achieve goals	27.32	32.525	0.817	0.738	0.912
Idea management system application has improved decision making	27.44	31.651	0.834	0.771	0.909
Idea management system application has improved information management	27.54	31.713	0.808	0.679	0.912
Idea management system application has improved overall management effectiveness	27.66	31.570	0.773	0.620	0.916
Idea management system application has helped to set the goals	27.84	29.884	0.793	0.677	0.914
Idea management system application has improved ability to respond to change	27.70	29.546	0.751	0.634	0.922

IV. CONCLUSIONS

In summary, the study aims to uncover underlying factors from a large amount of data collected on the results of a web-based IMS in relation to management and tangible results in companies. The researchers used factor analysis to identify latent factors and conducted a global survey of more than 500 enterprises that use these systems. They found that 8 variables fit together to reveal the latent factor "tangible results," and the remaining 6 variables fit together to reveal the latent factor "managerial results."

The purpose of the factor analysis was to identify the important factors that account for the variability in the results of the survey. The results of the factor analysis revealed that there are two important factors that account for the variability in the results of the survey. These two factors are the "tangible results" and the "management results." The tangible results are the underlying variables that explain the variability in the tangible outcomes of the survey. The management results are the underlying variables that explain the variability in the management outcomes of the survey.

The study likely has some limitations, as all research studies do. Some potential limitations of this study include:

- Self-selection bias: The survey participants were self-selected, meaning that they chose to participate in the survey. This means that the results may not be representative of the population of companies using web-based IMS.
- Limited sample size: The sample size of 500 enterprises is relatively small when considering the estimated number of companies using IMS is >120000. Therefore, the results may not be generalizable to the entire population of IMS users.
- Reliance on self-reported data: The survey relied on self-reported data from participants, which is subject to bias and inaccuracies.
- Lack of control group: The study did not include a control group of companies that do not use web-based IMS, which would have helped to better understand the specific benefits of IMS.

- Limited geographic scope: The survey was conducted globally, but it is not clear the distribution of the sample by country. Therefore, the results may not be generalizable to all geographic regions.
- Limited time frame: The survey data is a snapshot in time, and the results may not be generalizable to other time periods.
- The survey was distributed by IMS representatives, which may bias the results as well.
- The survey was designed to obtain a general view.

Future research in this area could focus on several key areas:

- Replication and extension of the study: The study could be replicated and extended to other industries and organizations to see if the results generalize to other settings.
- Comparison of different web-based IMS: The study could also compare different web-based IMS to see which one is most effective in terms of management and tangible results. And it should be researched also in different sizes of the companies [15;16].
- Examination of the effect of different organizational characteristics: The study could investigate how different organizational characteristics (e.g. size, industry, culture, etc.) impact the effectiveness of web-based IMS.
- Longitudinal studies: The study could conduct longitudinal research to understand how web-based IMS impact the organization over time.
- The effect of COVID-19 on the use of web-based IMS: The study could also investigate how the shift to remote work during the COVID-19 pandemic has affected the use of web-based IMS and the results they produce.
- The effect of artificial intelligence on the web-based IMS: Future research could investigate the integration of artificial intelligence into web-based IMS, and the impact that it has on the results they produce.

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Fuzzy Relations Based Intelligent Information Retrieval for Digital Library Users

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Abstract. **It is known that today information and library systems are one of the main sources of information needs of the population and have many users. Information and library systems have a large amount of valuable information resources and information retrieval services have been established to allow users to find the necessary literature. We know that search engines take requests and return results they think are relevant. As a result, the user again faces the problem of finding what he needs among the many sources of information provided.**
Today, a number of information systems effectively use recommendation systems based on artificial intelligence to recommend objects. In information and library systems, high efficiency can be achieved by identifying the information needs of users and recommending relevant literature.
To do this, it is necessary to determine the information needs of library users by analyzing information about their age, interests, level of knowledge in a particular area, previous requests, professions, etc. By introducing recommender systems into library information systems, it is possible to facilitate the work of librarians, increase speed and accuracy finding the necessary source of information, increase the efficiency of management and the level of satisfaction of the information needs of the population.
The article proposes a fuzzy model for solving the problem of assessing the needs of users of information and library systems and recommending relevant literature to them.

Keywords: Digital library, user needs, fuzzy relations, recommender systems, scientific and technical information.

I. INTRODUCTION

The human need for information has been studied as research in the field of librarianship, psychology and computer science since the 1950-1960s of the last century [1]. Charles Naumer and Karen Fisher in their work explained the process of studying the need for information through the idea of "human-computer symbiosis" [2]. According to him, people and computers should work together to solve problems related to information needs. People's information needs are also unique, such as areas of interest, knowledge levels in a particular area, goals, and other characteristics. Today, despite the availability of search engines and information databases with a large volume of information sources, it can be noted that there is a lack of work on creating information resource recommendation systems that meet the information needs of the user.

The increase in the amount of information is normal, and many digital libraries usually do not take into account parameters such as the level of knowledge, skills and characteristics of users. The available digital library search engines can be used in both simple and advanced modes, and they return sources of information that match the keywords entered, reflecting user queries. As a result, the user faces several more information sources.

Digital library systems can also use artificial intelligence and machine learning to help users find the information they need. The conducted studies emphasize that significant efficiency of library processes can be achieved through the use of artificial intelligence-based systems in digital libraries [3], [4]. The purpose of these systems is to determine the information needs of the user by analyzing information about him and recommending suitable content or services.

In the process of determining the information needs of digital library users, it is necessary to process ambiguous and incorrect information provided by

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linguistic variables, and the solution of this problem by deterministic or stochastic methods may not be effective enough. The purpose of this article is to study a fuzzy model for solving the problem of assessing the information needs of digital library users and recommending appropriate sources of information.

II. STAGES OF ASSESSING THE INFORMATION NEEDS OF DIGITAL LIBRARY USERS

In recent years, as artificial intelligence has developed, search engines have given way to recommender systems. Research shows that digital libraries can achieve greater efficiency by using recommender systems in finding information sources. The process of classifying users of digital libraries and sources of information according to a number of parameters plays an important role in creating a system of recommendatory sources of information in digital libraries. There are basically two types of recommender systems: recommender systems that aim to find similar sources of information or users with similar information needs [5]. For both of them the information needs of users can be identified in four steps.

a) Formation of types of information needs of users: At this stage, a set of parameters is formed, such as user interests, profession, age, demographic information, research areas, the level of knowledge in their field of science, and on their basis, possible information needs are classified. These actions are performed using either expert judgment or machine learning.

b) Collection of information about a specific user: Information about the registered user of the electronic library system is formed on the basis of previously known parameters. Naturally, not all parameters can be involved in this process.

c) Analysis of user data: At this stage, information about users is analyzed and it is determined what type of information needs they belong to. As a result, classes of users with the same information needs are formed. This allows you to recommend sources of information to users with similar information needs without expert judgment.

d) Create a user profile: At this stage, initial information about the user of the electronic library and data sets are created that characterize the dynamics of information needs.

III. ACCOUNTING FOR THE LEVEL OF COMPETENCE OF USERS IN THE AREA UNDER STUDY

When searching for information, it is necessary to take into account the level of competence of the user. Even the same information request can give a result that suits users in different ways. A survey was conducted of 148 users of 6 different levels of competence and education: Researcher, Lecturer, Engineer, Applicants for academic degrees, undergraduates and doctoral students, Student, Businessman. The respondents were people who work or study in the field of information technology.

Everyone was given the same question: "What types of information sources are more important to you? Please rate on a scale of 100. The following types of information sources were indicated: Scientific research (articles and books); Articles on technologies; Dissertations; Materials on professional technologies (scientific and applied reports); encyclopaedias; Standards; Textbooks, teaching materials; Articles on business.

The survey gave the following results. (Table 1).

TABLE 1 SURVEY RESULTS OF USERS OF DIFFERENT LEVELS COMPETENCE AND EDUCATION

#	**Interest Category and materials**	**Users**					
		Researcher	***Teacher***	***Engineer***	***Undergraduates and PhD students***	***Student***	***Businessman***
1	Scientific research (articles and books)	98.3	82.5	40.2	99.4	20.1	12.6
2	Articles on technology	22.4	32.1	99.2	70.3	56.6	42.2
3	Dissertations	99.6	80	56.7	98.7	15.6	10.4
4	Materials for prof. Technologies	51.4	50	99.6	50.4	47.3	21.3
5	Encyclopedias	92.4	63.9	51.3	54.3	42.4	11.2
6	Standards	10.6	32.5	90.4	41.5	21.5	52.4
7	Textbooks, teaching materials	71.4	100	43.1	72.8	99.7	12.5
8	Articles on business	22.5	20,5	47.1	31.6	13.1	99.8

As can be seen from Table 1, different categories of users have different needs by types of information sources. For users, they are close. For example, researchers and teachers may have similar requests. For others, they may differ dramatically. Accordingly, when forming search images (queries) and developing search algorithms in databases, it is necessary to take into account the categories of users. These search algorithms should allow "cutting off" the unnecessary and unimportant part of the search results, as well as providing more information that corresponds to users of this particular category.

Accounting for the category and competence of users should allow:

- Reduce the time of searching for information,
- Increase the share of the information that interests the user the most and reduce the share of non-important information.

To further reduce the amount of data that includes redundant information that may not be useful to the user, fuzzy correspondence models can be used [6]. These models of the type "Situation-Cause" and "Situation-Cause-Action" are used with situational advising systems

and have great prospects for solving problems that are difficult to formalize.

The use of fuzzy logic methods in the search for scientific and educational information is advisable if the following conditions are present:

a) Lack of an unambiguous correspondence between the request and the source of information;

b) The impossibility of arbitrarily accurate measurement of the amount and volume of data on search images;

c) The impossibility of a complete and clear description of the search image;

d) The inaccuracy of the functional actions performed by the system, which often do not achieve the goals set by the system when searching for data in the database;

e) Insufficient dimension of the model, which does not allow to reflect all the significant properties of the search object.

f) Not all query elements can be expressed in one or more words, even using Boolean algebra in its formation.

g) Insufficient "literacy" of the reader in the formulation of their requests.

IV. Algorithm for constructing a fuzzy composition

It is known that the information needs of a particular user are characterized by such parameters as his interests, level of knowledge in a particular area, goals, and these parameters are characterized by uncertainty. Therefore, the composition of fuzzy correspondence can be used to model the task of determining the need of a digital library user for sources of scientific and technical information and recommending suitable sources of information. In studies conducted on the construction of recommender systems using fuzzy correspondences and their composition, the high efficiency of this model was noted in solving problems of this type [7] , [8].

Let us construct a fuzzy model based on binary fuzzy relations $\tilde{S}$ and $\tilde{T}$. To construct the first relation, we will use two basic sets X and Y. For the second, we will use Y and Z. In this example, the set X describes the finite set of digital library users:$X = \{x_1,\ x_2,\ \dots x_n\}$. Y is the set of types of user information needs (TUIN) of electronic libraries: $Y = \{y_1,\ y,\ \dots y_m\}$. Z is a set of types of information sources in digital libraries: $Z = \{z_1,\ z_2,\ \dots z_l\}$.

In the context of this task, the relation $\tilde{S}$ will describe the characteristics of users of electronic libraries, and the relation $\tilde{T}$ will describe the qualitative indicators of the correspondence of information sources with types of users.

To find the correspondence $\tilde{S}$, the membership function $\mu_S(x,y)$ to the Cartesian product $X \times Y$ is constructed. Here $(x,y) \in X \times Y$. It should be noted that the $X \times Y$ correspondence table is filled in by the user himself.

In the Cartesian multiplication $Y \times Z$, the fuzzy correspondence $\tilde{T}$ is determined by the correspondence function $\mu_T(y,z)$. Here $(x,y) \in X \times Y$. Let us assume that the values of the membership functions were obtained by expert means or as a result of machine learning.

The fuzzy correspondence between $\tilde{S}$ and $\tilde{T}$ makes it possible to determine what type of user a digital library user belongs to and what sources of information are suitable for each type of user. Having built a composition of fuzzy matches $\tilde{S}$ and $\tilde{T}$, the stage of recommending which source of information is passed to each user:

$$\tilde{S} \circ \tilde{T} = \{(x,z), max_{y \subseteq Y}(\min(\mu_{\tilde{S}}(x,y), \min(\mu_{\tilde{T}}(y,z)))\} \quad (1)$$

or

$$\mu_{\tilde{S} \circ \tilde{T}}(x,z) = \bigvee_{y \subseteq Y}\{\mu_{\tilde{S}}(x,y) \wedge \mu_{\tilde{T}}(y,z)\} \quad (2)$$

here $x \in X$, $y \in Y$, $z \in Z$.

$\mu_{\tilde{S}}$ and $\mu_{\tilde{T}}$ are the membership function of fuzzy relations on fuzzy sets.

V. Example

Let the sets X, Y and Z be given in the following form:

$X = \{user_1,\ user_2,\ user_3\}$;

$Y = \{TUIN_1, TUIN_2, TUIN_3, TUIN_4,\}$;

$Y = \{source_1,\ source_2,\ source_3, source_4,\ source_4,\}$

TABLE 2 FUZZY RELATION $\tilde{S}$: "USER – TYPE OF USER INFORMATION NEEDS (TUIN)"

	TUIN1	**TUIN2**	**TUIN3**	**TUIN4**
User1	0.4	0.9	0.2	0.1
User2	0.3	0.5	1	0.2
User3	0.2	0.5	0.3	0.9

TABLE 3 FUZZY RELATION $\tilde{T}$: "TYPE OF USER INFORMATION NEEDS – SOURCE"

	Source1	**Source2**	**Source3**	**Source4**	**Source5**
TUIN1	0.5	0	0.3	0.7	1
TUIN2	0.9	0.6	0	0.2	0.6
TUIN3	0.7	1	0	0.6	0.3
TUIN4	0	0.2	0	0.5	1

At first we compute $\tilde{S} \circ \tilde{T}$ by using max-min composition.

$\mu_{\tilde{S}\circ\tilde{T}}(x_1, z_1) = \max\{\min(0.4, 0.5), \min(0.9, 0.9), min(0.2, 0.7), \min(0.1, 0)\} = max\{0.4,0.9, 0.2, 0\} = 0.9$
$\mu_{\tilde{S}\circ\tilde{T}}(x_2, z_1) = \max\{\min(0.3, 0.5), \min(0.5, 0.9), min(1, 0.7), \min(0.2, 0)\} = max\{0.3,0.5, 0.7, 0\} = 0.7$
$\mu_{\tilde{S}\circ\tilde{T}}(x_3, z_1) = \max\{\min(0.2, 0.5), \min(0.5, 0.9), min(0.3, 0.7), \min(0.9, 0)\} = max\{0.2,0.5, 0.3, 0\} = 0.5$
$\mu_{\tilde{S}\circ\tilde{T}}(x_1, z_2) = \max\{\min(0.4, 0), \min(0.9, 0.6), min(0.2, 1), \min(0.1, 0.2)\} = max\{0,0.6, 0.2, 0.2\} = 0.6$
$\mu_{\tilde{S}\circ\tilde{T}}(x_2, z_2) = \max\{\min(0.3, 0), \min(0.5, 0.6), min(1, 1), \min(0.2, 0.2)\} = max\{0,0.5, 1, 0.2\} = 1$
$\mu_{\tilde{S}\circ\tilde{T}}(x_3, z_2) = \max\{\min(0.2, 0), \min(0.5, 0.6), min(0.3, 1), \min(0.9, 0.2)\} = max\{0,0.5, 0.3, 0.2\} = 0.5$

Using max-min composition, we get the following result:

TABLE 3 FUZZY RELATION $\tilde{S} \circ \tilde{T}$: "USER – SOURCE"

	Source1	**Source2**	**Source3**	**Source4**	**Source5**
User1	0.9	0.6	0.3	0.4	0.6
User2	0.7	1	0.3	0.6	0.5
User3	0.5	0.5	0.2	0.5	0.9

Table 3 shows that *Source1* can be recommended for *User1*. *Source2* for *User2* is fully compatible, it is recommended to use *Source5* for *User2*. This algorithm can be used when the types of information needs of users are known.

VI. CONCLUSION AND FURTHER WORK

The proposed composition of fuzzy correspondences "user - user type" and "user type - information source" can be considered as the basis for building an expert system that allows users of digital libraries to recommend information sources suitable for their information needs. When the information needs of users need to be determined by several quantitative or qualitative parameters, each parameter can be specified in the form of fuzzy variables. Fuzzy modelling is more convenient in the process of describing and processing expert knowledge that is specified in linguistic variables.

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Automation of Feedback Analysis in Asynchronous E-learning

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***Abstract*. With the recent hit of the Pandemic study process is shifted to E-learning. Measuring the actual progress of a student in Asynchronous e-learning because of machine-human interaction and feedback is also considered a primary issue in this area. With the rapid development of artificial intelligence, computers can capture surroundings. Image processing is a rising technique in Artificial Intelligence (AI). Recognition of an individual's emotion helps identify the person's inner state. It is easy to measure a student's feedback about the session by doing it. The main functionality of this project is to capture the student's enough frames during the study session and provide the analysis of the average emotions to the administration panel. This prototype was used on 10 minutes of lecture to capture the emotion. The primary goal of this proposed system is to capture the learner's emotion at a specific interval during the e-learning session and provide the feedback of it to the instructor.**

Keywords: Computer vision, Convolutional neural network, E-learning, Emotion Feedback, Facial Expression.

I. Introduction

The word “feedback” is very familiar. Feedback can help to improve the quality of a session in many ways. Most of the study process continues with the traditional form of feedback. In the study process, the trainee immediately always gives the student feedback. It is usually given in facial expressions, gestures, or comments. The remaining problem in a study session is the student's genuine feedback after the completion of the session. It is easy to ask the learners to provide feedback in a traditional classroom study session. With the recent pandemic hit, the study process is shifted to digital sources known as E-learning [1]. Feedback is considered a problematic issue in higher education [2]. There is no proper definition of E-learning. Some E-learning reports went on to ask: Is E-learning creating a virtual environment to provide campus-based education? [3].

E-learning refers to communication technologies and information to enable the learning and teaching process. An E-learning system has a few of its characteristics. To begin with, it proposes a multimedia environment. In addition, it supports collaborative communication, whereby users have total control over their learning situation. E-learning is mainly divided into two parts – Synchronous and Asynchronous. Further, it is divided into more parts. Synchronous E-learning Is the interaction between human to humans through digital resources. It is also known as real-time learning. It creates a virtual classroom with the presence of the instructor or teacher. In this simultaneously, communication is possible between teacher-student and student-student. The most common mode used for this type of e-learning is video conference or audio conference. Asynchronous E-learning is the exact opposite of Synchronous E-learning. In this E-learning, leaner can adjust the learning time according to their schedule. There is no establishment of a virtual classroom between teacher and student in this E-learning. This E-learning can also be described as Self-study. The media used in this learning process is multimedia disks, external drives, or downloading forums. This learning is more popular than

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synchronous learning as learners can study according to their schedules [4]. Talking about e-learning session feedback in synchronous interaction takes place between human-human through digital resources, and taking feedback is not such a complicated task. As feedback Is considered the main factor in determining the success rate of a session, i.e., Was the trainee able to provide accurate information according to the session? Was the learner able to acquire all the information related? Is the learner ready for the next session? Identifying real-time feedback or feedback in synchronous e-learning depends on a few factors, i.e., body language, facial expression, or sentiments.

For human-to-human interaction, facial expressions are essential since expressions describe the current inner state and the actual reaction to the ongoing session [5]. Asynchronous E-learning is the interaction between a machine and a learner. It is not possible to get feedback in a live session. So, it is the possibility for Constructive feedback after the session. So genuine or accurate feedback from learners in asynchronous e-learning is still a problematic issue. Measure a student's success in the current session is almost impossible for the instructor or teacher. Facial expression also plays a vital role in the feedback area of any activity. This paper came up with the idea to capture human facial expressions via machine to find out the inner state of the learner during the session. Nowadays, with the help of AI, machines are smart enough to make decisions. AI is a sub-discipline of computer science. It is the most popular topic in today's time. AI takes over almost every field of humans. As their human exposure increased, the interaction became smoother and more natural. Nowadays, machines can capture environment surroundings through cameras and sensors. During the interaction between machines and humans, machines can capture human behaviour. In the past few years, deep learning algorithms have proven very successful. To better serve human affective computing, emotion detection is vital for machines. Aim of the study is to train a deep convolutional neural network with images of static facial emotions and use it as part of the software to detect their inner state during an asynchronous e-learning session. These results can improve the communication between students and lecturers and help improve how a teacher or course designer can make it more accessible or more attractive for a student [6].

II. Human Facial Emotion

The role of human facial expression in feedback plays a very vital role. Facial expression helps to understand the inner state of an individual on a deeper level [7]. To measure emotional responses, most research focused on recognizing the basic emotions. There are six different facial emotions. It is the most common feature of humans to react to any task. The primary six expressions are, i.e.- “Happy”, “Sad”, “Angry”, “Surprise”, “Neutral”, “Disgust”.

Above written expressions are the most common for every face. It is also customary to understand any human by its manifestations. In different types of emotions, human face muscles make various movements. A simple difference is visible in the Fig. 1.

Fig. 1. Different states of human facial expression (source: [11]).

The image of the left side presents a different expression from the image of the right side. It shows how a person reacts to different situations. Normal taking this concept to a study room session. In the case of Synchronous E-learning, Its interaction between human-to-human faces. So recognizing a student's expression in session can be easily identified by the teacher. If a student feels happy, it is understandable that they are learning something new and are pleased with the session. Every expression has its characteristics. i.e.

Sad – It indicates a student is not mentally ready for this session.

Happy – It indicates a student is enjoying the session.

III. Neural Networks

It is an approach inspired by the human brain and teaches a computer to process data. It creates an adaptive system in that computer improves themselves by learning from their mistakes. It is a significant branch of AI (see Fig. 2).

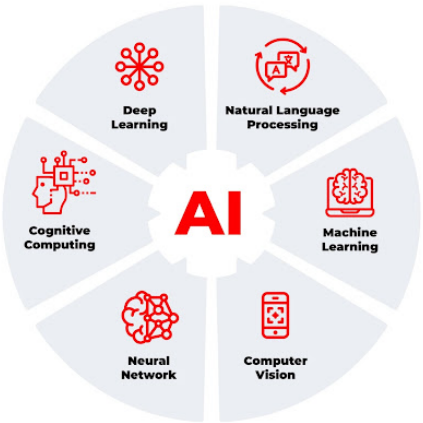

Fig. 2. Branches of AI (source: https://10pie.com).

The main characteristic of a Neural Network (NN) are following. It helps to solve problems and make intelligent decisions without human assistance. NN analyze raw data profoundly and reveal new insights for which they might not have been trained. In today's time, usage of the NN is in many industries, i.e., medical diagnosis, target marketing, financial predictions etc. [8]. NN have different types, but this paper focuses explicitly on Convolutional

Neural Networks (CNN). CNN is beneficial for image classification because it can extract features from images for recognition and classification. The main advantage of CNN is that it automatically detects the essential features without human supervision. CNN aim to use information between the pixel of an image [9]. CNN is primarily used to classify images. CNN can recognize street signs, animals, and human faces using many algorithms. The correlation between CNN and feedback is Human behaviour. As mentioned above, human facial expressions are a very critical characteristic. With the use of CNN, it is effortless to capture human facial expressions from a live feed during the session. Human facial has a limited number of expressions. i.e., Happy, Sad, Angry, Neutral, disgusted, Surprise. CNN can identify these expressions. Further, these results can be used to improve the quality of education. The parameters used to train the CNN are mentioned in the Implementation chapter.

Fundamentally, CNN architecture combines two main parts (see Fig. 3).

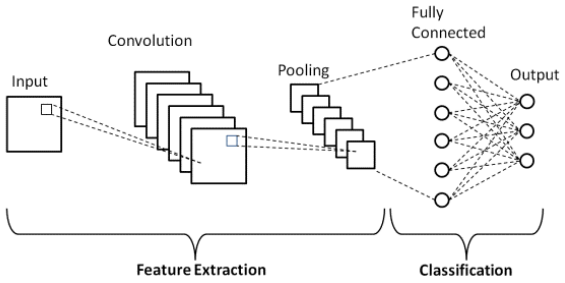

Fig. 3. Architecture of CNN (source: https://www.upgrad.com/blog/basic-cnn-architecture/).

Feature extraction – this layer slides over the input data and identifies the various information. This process is called feature extraction.

Classification - this layer utilizes the output from the process and predicts the image class based on the feature extraction process.

Simple example of objection detection by CNN see in Fig. 4.

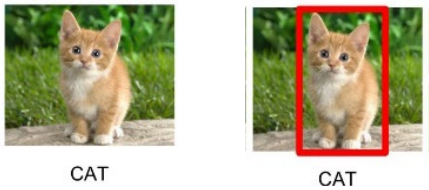

Fig. 4. Objection detection by CNN (source: https://www.alibabacloud.com/blog/).

The first image is the sample image used to check whether that cat is available or not in the image. This image was feed in to the trained CNN to check the cat is present in this picture. After putting visualization, it can detect a cat.

IV. MATERIALS AND METHODS

The complete process of automation of feedback analysis is divided into three modules.

A. Frame extraction with face detection

The first step is to extract the frames from the live feed or video with face detection. A live feed is a collection of frames per second, so the extraction is done by writing a simple frame extraction program in python language. Many approaches, methods, and techniques for detecting a human face in a digital image. In the 1960s, Woodrow Wilson Bledsoe manually implemented recognition of a face. Detection of the object in the digital image is connected to computer vision.

The main aim of the detection of face algorithm is to determine whether there is a face or not in the given image. Face detection can be done via different methods, i.e. knowledge-based, appearance-based, feature-based, and template-matching using a Deep Neural Network (DNN). However, detection of the face could be done by DNN, but a predefined computer vision library named "OpenCV" was used to detect the face. It is an open-source library. This library contains around 500 functions that span many areas of computer vision, and detecting an object is one of them [10]. This library helps to use computer vision algorithms straightforwardly. The primary advantage of using OpenCV is highly optimized and available on all popular platforms. Haar cascade classifier algorithm is used to detect the face in the given video.

The main reason behind using computer vision instead of using a NN for detection is that it can detect faces during the live feed. So the frame will extract only based on the face detected in that frame. If the program does not detect a face in a frame, it will take another frame instead of without a face and store it in the user's unique directory. A course designer can define how many total frames are required to measure the learner's progress. In this paper, the author assumes the session is about 10 minutes and extracts frames after every 10 seconds. The total number of frames will be 60.

B. Analysis of facial emotion

The extracted frame result from the Haar cascade classifier algorithm will be directly forward to the trained CNN to analyze the emotion. The program will run a loop to check emotion on every single frame. Results from every single frame will be stored in relevant information holding variable to the emotion.

C. Analysis of result and improvement process

The teacher will analyze the results at the end of the session; after the analysis, the teacher will take the necessary steps (see Fig. 5). In case the teacher feels the student needs to improve the previous session, then the student will retake the same session with the improvement of content; on the other hand, if the teacher feels improvement in the content of the next session can take the result for the overall course to a satisfactory level. In that case, the content of the next session will be updated before the session. The improvement process will be repeated until the result of the current session reaches a satisfactory level.

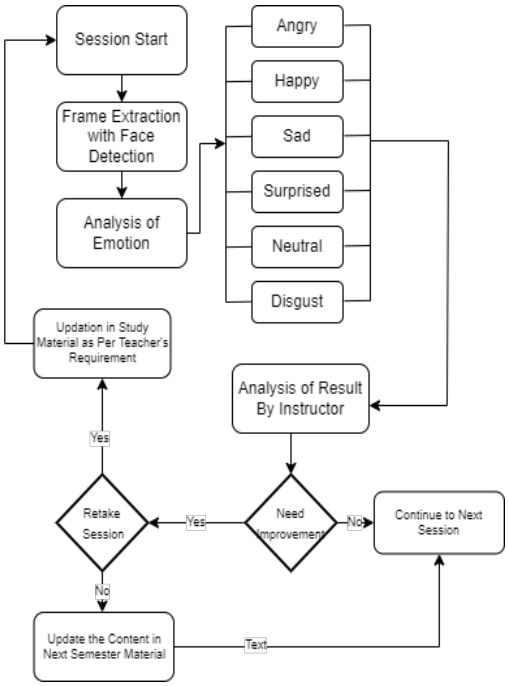

Fig. 5. Structure of the emotion analysis system.

V. IMPLEMENTATION

A. Dataset

Dataset is a set of collections used to train a network for future predictions. Dataset can be in graphical form as well as in tabular form. In tabular form, each row contains pixel values of the image or corresponds to a given data record, and each column represents a particular variable. It can be collections of files or documents.

The dataset used in this research contains 30000 images with the size of 48*48 mm and a bit-depth of 8 bits. The name of the dataset is FER2013, and this dataset is available on the internet [11]. The dataset credit goes to Pierre-Luc Carrier and Aaron Courville. The images used are of people representing six different emotions. For the training of the CNN, 90% dataset was used, and the remaining dataset was used for testing purposes. The sample of used images see in Fig. 6.

These images represent emotional happiness. Similarly, all emotions have such kinds of images. For each emotion, around 5000+ images were used for training purposes, which helped maximize the model's accuracy.

B. Training Process

The training process of CNN basically making a layers structure to feed the data for learning process. Training process can also be called learning process. In this process model use to learn from the data samples. The layer structures which is used to train model is given in Fig. 7.

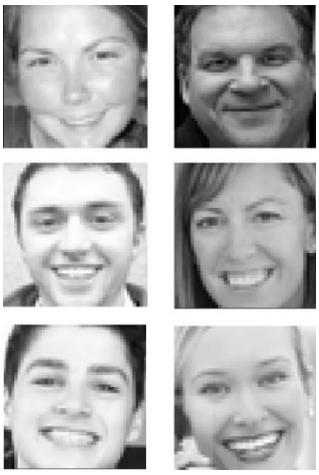

Fig. 6. Sample dataset images (source: [11]).

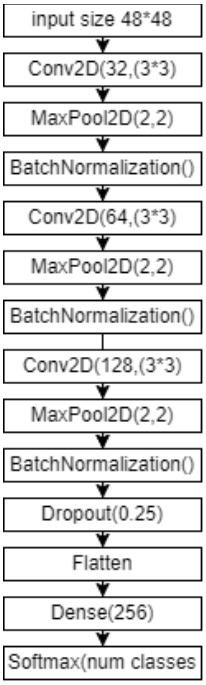

Fig. 7. Structure of CNN.

The current accuracy achieved with the CNN structure with the above mentioned dataset is 72%.

C. Frame extraction from live feed

Live feed is a massive volume object with a piece of insensitive information and high redundancy. It has a complex structure with the scene, shot or frames. One of the fundamental units in structure analysis is the Key-frame extraction. The first step is to extract the frame from the live feed. Extracting frames is a separate process in this project. It doesn't use any algorithm used for feedback analysis. Every second is very important to analyze the learner's emotions during the event. Thus, a separate set of commands is defined for frame extraction, which allows extracting the frames as per the course designer's request. This program was tested with a sample session of 10 minutes, and some of the extracted frames from live feeds are following (see Fig. 8).

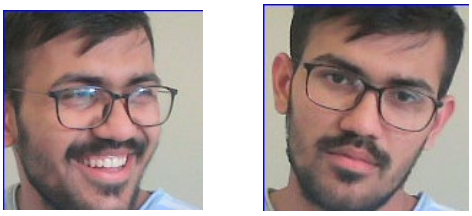

Fig. 8. Extracted frames from live feed (source: personal archive).

Analysis of emotion

The programs will run in a loop to detect the emotion. Every emotion output will be stored in different variables to calculate the learner's average emotion status during the session. After detecting emotion from all frames, the result will be present in the graphical bar on the teacher's panel to measure student progress.

Result

After calculating the learners' emotional states, in the below bar, the results are presented (see Fig. 9).

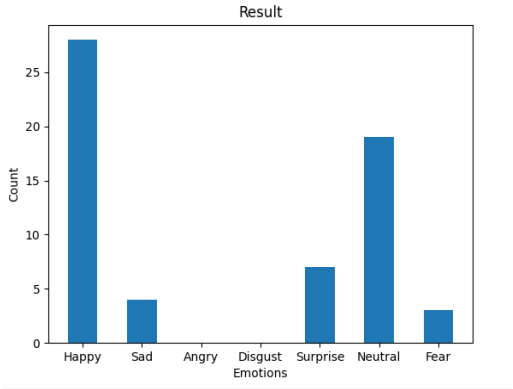

Fig. 9. Bar graph showing emotion states of learner.

These results are from 10 minutes of demo sessions with 60 frames. These results will be visible only to the teacher. So for them, it's straightforward to measure the learner's success during the session if we talk about the above result. It is effortless for a teacher to understand how the session went without the presence. As a result, shows max states of emotion and was happy in the session. In simple words, the learner enjoyed the session.

VI. Learning Analytics

Learning Analytics is the new trend in digital learning. The popular explanation of Learning Analytics includes the "measurement, collection, analysis and reporting of data about learners and their contexts". The Learning Analytics aims to optimize the learning. Most of the Learning Analytics solutions are using the data sets similar to traditional education. The face emotion detection has the great potential to extend and enrich Learning Analytics data set and usability.

The next step we see the complimentary extension of Learning Analytics data set with Knowledge Acquisition Monitoring [12]. The both technologies could create the fast feedback for update of learning content and delivery approach.

VII. Conclusions

Although automatic detection of the face in today's time is not so tricky, detecting a tilted face is a complex task. The most challenging part is to train the CNN repeatedly to get better results and accuracy to detect the emotion more accurately. These results will be used as feedback from the student in live sessions. It will help make the content much more exciting and accessible for students.

In future, we will develop this project by adding keynotes to a study session to measure the progress more accurately. We will retrain the model through with transfer learning to achieve more accuracy. This project will be implemented into a Moodle system also. Apart from this, we will develop this project with more actions of the user, such as sitting pose or voice input, to measure the student's learning progress in a much more accurate way.

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Formation of the Knowledge Base of Digital Libraries Based on Semantic Models of Authority Files

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Abstract. **This article is devoted to the analysis of methods for creating a knowledge base of a digital library based on the semantic model of authority files. The article also describes the practical aspects of creating an electronic library legal encyclopedia based on the semantic model of authority files. It is worth noting that the creation of a semantic network of authority files significantly optimizes the quality and speed of searching for resources in electronic libraries and creates the basis for meaningful literature search by readers. The article examines in detail the existing approaches to creating a knowledge base of authority files, including files based on semantic models, and forming a knowledge base structure. The main purpose of the study is to create an improved model and develop software for creating a knowledge base of an electronic library of semantic authority files for various subject areas. In the article the theoretical research methods (method of comparison and critical thinking) and empirical research methods (data collection and document analysis) have been applied. Used object-oriented programming, intelligent search, reverse indexing capabilities. The field of jurisprudence was chosen for the application and approbation of the created model and software. A knowledge base has been created that studies frequently used specialized terms and semantic relationships between them.**

Keywords: authority files, knowledge base, reverse indexing, semantic network, thesaurus, term.

I. INTRODUCTION

In this article, we consider the methods of forming a knowledge base for information systems designed to quickly and qualitatively search for literature in specialized digital libraries. The article uses theoretical research methods (comparison and critical thinking method) and empirical research methods (data collection and document analysis).

In recent years, information and information services have become an extremely important and, at the same time, changing part of the mission objectives of the library institution. While ever-expanding electronic resources and ever-increasing access to digitized materials are changing the nature of information, the content of service remains central. Every day, librarians and their readers are confronted with a large number of information sources that must be constantly evaluated for reliability. Even when a person is in front of a computer and facing a world of documents, he is sure to feel like he is drowning in a sea of information. After all, new media and technologies, like tributaries, contribute to this new sea of knowledge and serve to increase its size and scale. And the information services are naturally both a lifeboat and a map and compass for those who are overboard and lost. By providing timely and special services to such readers, libraries are practically confirming that they are one of the central institutions of the 21st century. Broadly speaking, referral service is the

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process of assisting library users in identifying information sources that may answer their specific question, interest, task, or problem. In the modern world, the introduction of literature search and delivery services that can fully satisfy the needs of readers has become a rather complicated process. Especially scientific and educational questions are somewhat more complex to answer and may require more time and information resources to provide a complete answer.

At the same time, it is important how complete and reliable the information or information source provided by the librarian is to the reader's request. Accuracy, reliability, coverage and relevance determine the value of the information provided.

Accuracy is the most important criterion for the information presented. Given that this information will later be used to make decisions for another situation, the accuracy of the information is of the utmost importance. Therefore, any information provided must be accurate.

Reliability. In most cases, the credibility of the publisher or author who published the literature containing the information determines the level of credibility of the information presented.

Coverage. Information on a narrow topic is important to be effective. Readers are interested in a wide coverage of a narrow topic of literature and getting additional information about it. Adequate coverage determines the completeness of the information being conveyed. If the librarian is satisfied with the answer, he will not spend too much time to send a new request for additional information.

The purpose of the article. The main goal of this study is to improve the semantic models of creating a knowledge repository that serves to improve the efficiency of semantic search of authority files.

II. Materials and methods

The methods and technologies used in creating an electronic library system are determined based on the number and scope of users of this system. Nowadays, electronic information-library networks of a smaller size, which provide specific information on a specific specialty, are mainly used in the systems of higher education institutions, scientific research institutes, and some state organizations. From this point of view, in order to increase the effectiveness of their activities, to form professional, spiritual qualities and a broad worldview in students and employees, they are creating information-library systems based on their needs and using them effectively. One of such directions is the direction of jurisprudence, which creates a wide range of opportunities for exchanging information with each other through the mutual integration of unique electronic resources accumulated over many years in higher educational institutions engaged in education in this specialty.

Many legal scholars and statesmen have worked in the Republic of Uzbekistan. During their career, they achieved many scientific achievements, published the results of their scientific activities in one form or another. One of the main problems in this direction is that a single electronic database of the developments of such mature scientists has not been created. In order to solve this problem, using the capabilities of modern information technologies, we have conducted research in the direction of creating a unified system of semantically linked authority files for the specialty of jurisprudence based on intellectual search by conducting new scientific experiments and semantically linking authority files with the help of improved methods.

Searching for the necessary information quickly and qualitatively in the information space, which is increasing day by day, cannot be done by one action. To implement this complex task, it is important to implement several information processes, and most importantly, to limit the human factor. The reason is that the volume of information is increasing so much that it has become impossible to process it with human participation. Therefore, solving these tasks requires the effective use of artificial intelligence technologies. Artificial intelligence technologies, on the other hand, originated from the field of science, and widely use large amounts of data to find effective solutions to given tasks. Several scholars have explored the issue of using big data as a knowledge repository, and classification issues in big data are discussed by Pijush Kanti Dutta Pramanik (https://orcid.org/0000-0001-9438-9309) Moutan Mukhopadhyay & Saurabh Pal, A Machine Learning Platform for NLP in Big Data issues Mauro Mazzei, Semantic Information Retrieval Systems Costing in Big Data Environment Khalid Mahmood, M. Rahmah, Md. Manjur Ahmed & Muhammad Ahsan Raza, Semantic Model Driven Engineering Challenge Milward, D. M. (2020).[1]-[2]

Evaluation of Distributional Semantic Models for the Extraction of Semantic Relations for Named Rivers from a Small Specialized Corpus issues Rojas-Garcia, J., & Faber, P. (2019). A Bi-model based RNN Semantic Frame Parsing Model for Intent Detection and Slot Filling was studied by Wang, Y., Shen, Y., & Jin, H. (2018) in Searching Data: A Review of Observational Data Retrieval Practices in Selected Disciplines Matter Gregory, K., Groth, P., Cousijn, H., Scharnhorst, A., & Wyatt, S. (2020). Machine learning based data retrieval for inverse scattering problems with incomplete data problems Gao, Y., & Zhang, K. (2019). The Search for Thinking Machines issues Ashri, R. (2020).[3]-[8]

The issues considered in their work are very deeply analyzed and rich in content, mainly dedicated to working with large volumes of giant data located on the open Internet. Such methods may not provide sufficient results when used with small and medium-sized data. For this reason, the development of accurate information return methods and the creation of a knowledge repository remain a very urgent issue when working with specialized data.

III. Results and Discussion

Knowledge warehouse (KW) is a type of information warehouse that contains information on human experience and knowledge in a certain field of science and is created to manage, collect, store, search, and present this knowledge. BO means a set of facts and rules that allow meaningful processing of data and logical conclusions. BO is expressed in the form of rules and specific facts, providing knowledge and details about people, objects, events, facts, making logical conclusions on information processing processes and data storage.

Three main principles should be embodied on the basis of a successful, comprehensive knowledge base:

- Understandability
- Payment
- To be useful

To be understandable to everyone. Regardless of who uses it, information in the knowledge base should be understandable. Information should not be too long or too short. It is desirable that the text should consist of a sequence of words with the same meaning and should not contain complex sentences. In some cases, knowledge repository information may seem convenient to the "learner", but it may be too simple for the "professor". In short, finding the "norm" becomes a difficult task.

There are several ways to solve such problems:

1. Review by a senior expert in the field of science. This process is aimed at increasing the quality of the knowledge repository (KB) materials. The expert checks the correct expression of the material and its logical sequence.
2. By establishing a feedback relationship with the user who used the material, getting his opinions and comments about expanding, shortening, and creating the material. Through feedback, the user can leave any suggestions that are important for him. Also, the user can leave his feedback in the form of various signs and thank you notes.
3. Systematization. This tool can be conditionally divided into two effects:

- administrative effects - bringing information to a unified regulatory view, the procedure for identifying changes, etc.
- technical solution - use additional settings to hide details, display only in necessary situations. It solves the problem of providing information for users of different levels: it meets the requirements of maximum concise and professional language for experts, and the meanings of terms are explained in detail by providing details to novice users.

Always relevant. It is necessary to pay great attention to the fact that the information placed in the repository of knowledge is constantly available. It is necessary to maintain the confidence of all users in the repository of knowledge and its materials. It is important that the knowledge warehouse manager has a monitoring system that provides a good service that responds to incidents. For example, for the knowledge base of the information system support service, there will be interpretations, changes in legislation and other tasks. Self-starting services determine the people responsible for responding to the incident and distribute the tasks. In order to successfully carry out updates in the system, it is necessary to have an understanding of how to improve the system at the stage of its creation and form it taking into account all situations.

We can use a classifier and a known transition algorithm model as a tool for automatic classification of materials included in the knowledge repository.

List of neighbors. An adjacency list represents a graph as a list of linked arrays. An array index represents a node, and other vertices in the list represent other vertices connected to it by an edge. The neighbor list only stores values that have connections through edges. On large graphs, this saves significant memory.

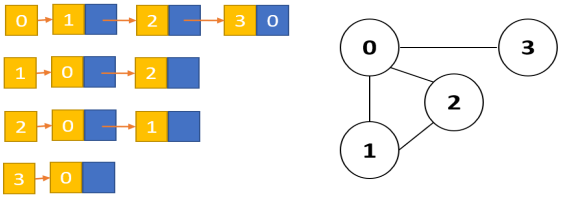

Fig.1. List of neighbors.

A spanning tree is an undirected graph partition that connects all the nodes of the graph with the minimum possible number of edges. The length (value) of the edges can be specified or unspecified.

If we have n=4 the chance of creating spanning trees is $\mathbf{4^{4-2} = 16}$.

One of the most important steps in creating a knowledge base is to organize the existing information. In this process, we use the most popular Merge sort algorithm.

Marge sort algorithm. Marge sort is one of the most popular sorting algorithms and works on the principle of "divide and conquer". According to the principle of operation of this algorithm, a large task is divided into several small separate tasks and each small task is performed in a separate order. Finally, sub-tasks are again iteratively combined into a holistic form.

In our project, the researched task is directly related to the hierarchical data structure, and we used the recursive function because we aimed to achieve the most optimal results. The recursive function is mainly used in database design and creation. In this article, we will use the following program code implemented in the database of our research.

```
WITH RECURSIVE terms_tree as (
 select
  e1.id,
  e1.parent_id,
  e1.term_username,
  0 as term_level,
  e1.id::VARCHAR as term_id_id
 from terms e1
 where e1.id = 2
 union all
 select
  e2.id,
  e2.parent_id,
  e2.term_username,
  term_level+1,
  term_id_id::VARCHAR || ',' || e2.id::VARCHAR
  from terms e2
 join terms_tree et on et.id = e2.supervisor_id
) select * from terms_tree;
```

IV. CONCLUSIONS

One of the most important steps in creating a knowledge base is to organize the existing information. In this process, use the most popular Merge sort algorithm.

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Subjective Probabilities Elicitation and Combination in Risk Assessments Problems

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Abstract. **Very many areas of human activity are associated with greater or lesser risks. In order to make reasonable decisions, these risks must be properly assessed. The consequences of any risk can be characterized on the basis of two fundamental dimensions (metrics): (1) losses associated with the outcomes of implementation an unfavourable event; (2) probabilities that quantify the uncertainties in the occurrence of these outcomes. This article in a concise form presents and analyses approaches to subjective probabilities elicitation and combining the obtained individual estimates in group subjective probabilities estimation.**

Keywords: risks, subjective probabilities elicitation, subjective probabilistic estimates combination, unfavourable event's outcomes.

I. INTRODUCTION

Almost all people are well aware that any risks are associated with some unfavourable circumstances (events). Such events can be various kinds of natural disasters, fires, vehicle accidents, financial losses, injuries, epidemics, and many others.

Usually, any individual on a subconscious, intuitive level definitely understands what risk is. But if you ask him to give a formal definition of risk, he will definitely be at a loss to give a meaningful definition of this concept. As figuratively noted in [1], if you ask ten different people what they mean by the word "risk", you will probably get ten different answers.

A large number of formal definitions of risk have been proposed. Sufficiently broad summaries of such definitions are presented in [2], [3]. As an example, we present a summary of definitions from [3] without references to original sources.

1. Risk is an estimate of the probabilities and weights of unfavourable consequences.
2. Risk is a set of triplets (s_i, p_i, c_i), where s_i - i-th scenario, p_i - likelihood of the scenario, s_i, c_i - consequences of the scenario s_i, $i = 1,...,N$.
3. Risk is equal to the product of probability and damage.
4. Risk is a situation or event where human values (including people themselves) are accepted as bets where the outcomes are uncertain.
5. Risk is a combination of primitive concepts: outcome, likelihood, importance, causal scenario, and identified population.
6. Risk is an expression of the influence and possibility of an accident in terms of the severity of the potential accident and the likelihood developments.
7. Risk is a combination of probabilities and limits of consequences.
8. Risk is the uncertainty of an event or activity associated with some human values.
9. Risk is equal to the expected damage.
10. Risk is the likelihood of injury, illness or harm to health because of the dangers.
11. Risk is the effect of uncertainty on goals.

In this work, the definition presented in [2] is taken as a basis. "*Risk refers to uncertainties about the extent to*

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which events and their consequences (or their outcomes) affect what constitutes human value".

At a lower level, risk can be given an operational definition [1]. Such a definition specifies the concepts of factors included in the abstract definition of risk.

The instrumental level of definition contains the expression of risk in terms of one or more risk metrics. The term *risk metric* is used interchangeably with *risk assessment* and is defined as "a mathematical function of probability of an event and the consequences of that event".

Reference [4] provides conceptual definitions of risks. The main procedures (risk assessment and management) are presented in ISO 31000 [4], ISO 31010 [5].

The following concepts and definitions are taken from ISO 31010 [5].

- *Risk assignment* is the overall process of risk identification, risk analysis and risk assessment.
- *Risk analysis* is the process of recognizing the nature of risk and determining the level of risk.
- *Risk assessment* is the process of comparing the results of a risk analysis with risk criteria to determine whether the risk and/or its magnitude is supportable or tolerable.

Two factors (dimensions) are used to characterize any risk: (1) losses associated with the outcomes of an unfavourable event; (2) estimates of uncertainties in the occurrence of outcomes.

Subjective estimation of probabilities is widely used in situations where, due to the lack of statistical data, an objective estimation of these probabilities is impossible. Examples of such situations might be:

- Assignment of risks when making decisions on the strategic development of a business (Choosing the country where a new enterprise is located, making a decision on the release of new products, making a decision on investing in risky activities).
- Assigning risks to political decisions regarding relations with partner countries and hostile countries.
- Appointment of risks when planning decisions during military conflicts.
- Assessment of environmental risks (risks of negative impacts on the environment, risks of negative impacts of the external environment on infrastructure facilities and searches for negative impacts of invasive plant and animal populations).

The purpose of this paper is to present the most common methods for the subjective evaluation of deterministic values of probabilities in risk assignment problems.

II. Subjective Probabilistic Estimates Elicitation

In the subjective assessment of probabilities in the problems of risk assessment, they deal with fundamentally different types of uncertainties.

- *Aleatory uncertainty*, which refers to the chances of occurring the outcomes of unfavourable events. This uncertainty is an inherent property of the phenomena of the world around us. The task of the expert (experts) is to quantify the relevant aleatory uncertainties using probabilistic estimates.

- *Epistemic uncertainty* characterize the degree of confidence of the expert (experts) regarding the estimated probabilities values. When performing expert estimates of probabilities, all possible conditions must be provided to reduce epistemic uncertainties.

The processes of expert estimation of probabilities are presented in details in industry guidelines [7 - 10]. Detailed information on probabilities elicitation can also be found in [11].

In general, approaches to probability-based characterization of uncertainties can be divided into five big categories [8]:

- frequency;

- based on judgments / subjective;

- scenario analysis;

- others (interval probabilities, fuzzy logic, meta-analysis);

- methods of sensitivity analysis.

The approaches considered in this paper explicitly belong to the 2nd category.

Let us present widely used approaches to elicitation of subjective probabilities.

1. *Direct estimation of relevant probabilities*. Alternatively, this method is called the *fixed probability method.*

Using knowledge and experience, the expert directly assigns the required probabilistic estimates. It can express the uncertainty of its judgments with the help of fractiles and extreme values for the estimated point values (see Fig. 1).

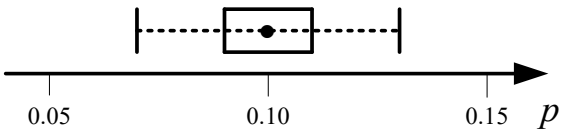

Fig. 1. Graphical representation of the uncertainty of expert with respect to the actual value of the estimated probability.

In this figure, the dot represents the median (average) assessment of expert. The values $p = 0.09$ and $p = 0.11$ correspond to fractiles 0.25 and 0.75. The values $p = 0.07$ and $p = 0.13$ are the extreme possible values of the estimated probability.

2. *Preliminary verbal estimation of probabilities.*

This approach is based on the fact that verbal categories of values of the estimated probabilities are determined first [12]. As an example, Table 1 presents a possible option for determining verbal categories on a set of probabilistic estimates.

TABLE 1 VERBAL VALUES OF PROBABILITIES AND CORRESPONDING INTERVALS OF PERCENTAGE VALUES OF THESE PROBABILITIES

Verbal categories	Percentage values of probabilities
In higher degree no chance	01 – 05%
Very implausible	05 – 20%
Implausible	20 – 45%
About the same chances	45 – 55%
Plausible	55 – 80%
Very plausible	80 – 95%
In higher degree plausible	95 – 99%

Verbal assessments of probabilities of outcomes and losses associated with these outcomes are used in formalization of risk matrices to categorize existing risks. However, in many risk assessment problems, the probabilities of all outcomes can have rather small values. Therefore, the use of verbal categories similar to those presented in Table 1 seems inappropriate. In such cases, it may be recommended to develop a specific system of verbal categories corresponding to the possible numerical values of the probabilities in a particular task of risk assessment. Using such a system, an expert can first set verbal categories for the estimated probabilities and, on this basis, subsequently proceed to numerical estimates of the required probabilities.

3. *Use of reference lotteries*.

The idea of this approach is to use specific lotteries, on the basis of which the probabilities of interest can be estimated. First, a lottery is set, the outcomes of which are understandable and acceptable to the expert. One of the lottery outcomes must be clearly preferable to the other. For example, consider a lottery with the following outcomes:

Outcome 1 - getting a new luxury car if outcome A comes true.

Outcome 2 - free lunch at a restaurant if outcome A does not come true.

The outcomes of the second lottery are the same, but they are related to the probabilities of the implementation and non-implementation of outcome A. This lottery is called the *reference lottery*. Both lotteries are presented in Fig. 2 in the form of a decision tree.

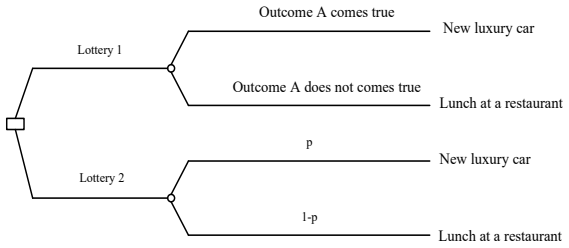

Fig. 2. Decision tree for estimating the probability of outcome A by comparing lotteries.

The expert is asked to determine such a value of probability, at which he will be indifferent in which of the lotteries to take part.

4. *Pairwise comparison of the plausibility of outcomes.*

With a large number of outcomes of an unfavourable event, assigning their probabilities becomes difficult for an expert. In [13], it is proposed to use the approach - the analytic hierarchy process (AHP) [14], with the help of which the process of subjective estimation of probabilities is reduced to a paired comparison of outcomes according to the degree of plausibility of their implementation. Additional information about AHP can also be found in [15].

Let an unfavourable event be associated with outcomes $o_1,..,o_n$. These outcomes are presented in the 1st row and 1st column of Table 2. The value $s_{ij}, i, j = 1,...,n$, in the corresponding cell of the table represents an expert assessment of the superiority in chances of the outcome o_i over the chances of the outcome o_j. Evaluation is made on a 9-point scale Saaty [14]. Note, that the diagonal cells of the table contain 1 and $s_{ji} = 1/s_{ij}$.

TABLE 2 RESULTS OF PAIRWISE COMPARISON OF OUTCOMES IN TERMS OF THE DEGREE OF PLAUSIBILITY OF THEIR IMPLEMENTATION

	o_1	o_2	⋯	o_{n-1}	o_n
o_1	1	s_{12}	⋯	$s_{1,n-1}$	s_{1n}
o_2	s_{21}	1	⋯	$s_{2,n-1}$	s_{2n}
⋯	⋯	⋯	⋯	⋯	⋯
o_{n-1}	$s_{n-1,1}$	$s_{n-1,2}$	⋯	1	$s_{n-1,n}$
o_{n1}	s_{n1}	s_{n2}	⋯	$s_{n,n-1}$	s_{nn}
	$\sum_{i=1}^{n} s_{i1}$	$\sum_{i=1}^{n} s_{i2}$	⋯	$\sum_{i=1}^{n} s_{i,n-1}$	$\sum_{i=1}^{n} s_{in}$

After filling the table, the sums of values $\sum_{i=1}^{n} s_{ij}$ in its columns are calculated and the original values s_{ij} are normalized relative to these sums. Another table is compiled containing the calculated normalized values s_{ij}^n.

Next, the normalized eigenvector of the pairwise comparison table is determined $W = \{w_i / i = 1,...,n\}$. i -th component of vector w_i is calculated by the expression

$$w_i = \sum_{j=1}^{n} s_{ji} / n \ , \ i = 1,...,n \ , \tag{1}$$

where n - the number of outcomes.

The values w_i are taken as estimated values of the probabilities of outcomes $p(o_i)$.

To assess the degree of consistency of the expert's subjective assessments, the following sequence of calculation procedures is performed.

1. The *main eigenvalue* of the table is calculated

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{w_i}{\sum_{i=1}^{n} s_{ij}}, \ j = 1,...,n, \tag{2}$$

2. The *index of consistency* of pairwise comparisons is calculated by the expression

$$CI = \frac{\lambda_{\max} - n}{n}. \tag{3}$$

3. From Table 3, the value of *random consistency index* RI is determined. These values are a function of the number of pairwise comparisons n .

4. The value of the *consistency ratio* CR is calculated

$$CR = \frac{CI}{RI}. \tag{4}$$

TABLE 3 RANDOM CONSISTENCY INDEX VALUES RI

n	RI
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

With values $CR < 0.10$, the results of pairwise comparisons are considered to be reasonably consistent. With values $CR > 0.10$, the expert may be asked to clarify all or some of the results of his pairwise comparisons.

III. COMBINATION OF SUBJECTIVE PROBABILITIES

If probabilities elicitation is performed by a group of experts, the problem of combining individual expert assessments appears. Let us present some formal methods for solving this problem based on the data presented in [16].

1. *Linear opinion pool.*

Let expert estimation of the probability of some outcome o_j be performed by n experts. The combined estimate of this probability can be calculated by the expression

$$p(o_j) = \sum_{i=1}^{n} w_i p_{ij} \tag{5}$$

where p_{ij} - evaluation of the probability of the outcome o_j by the i-th expert; w_i , $i = 1,...,n$, - weight given to the assessment of the i-th expert.

The value $p(o_j)$ is a weighted linear combination of the assessments p_{ij} . Weight w_i characterizes the degree of confidence in the assessment of the i-th expert.

The combined assessment $p(o_j)$ satisfies the unanimity property: if all experts agree with their own assessments, they must agree with the combined assessment.

2. *Logarithmic opinion pool.*

The combined value $p(o_j)$ can be calculated by the expression

$$p(o_j) = k \prod_{i=1}^{n} (p_{ij})^{w_i} \ , \tag{6}$$

where k - normalizing constant.

As noted in [16], expression (6) satisfies the external Bayesian principle. Let us assume that the combined value of the probability $p(o_j)$ is calculated from expression (6) and new information is obtained, on the basis of which the values p_{ij} and $p(o_j)$ can be re-evaluated. There are two alternative ways to perform such a re-evaluation: (1) first, using new information, experts re-evaluate their initial estimates p_{ij} , then the new estimates are combined according to expression (6); (2) using the new information, the resulting value $p(o_j)$ is re-evaluated. According to the external Bayesian principle, the results should match in both cases.

3. *Bayesian combination of probabilities.*

In [16], four variants of such a combination are presented. Let's present one of the most used options. Let p_{ij} , $i = 1,...,n$ be the probability estimated by the i-th expert that the outcome o_j will come true. Expressed in terms of posterior odds, the credibility of the outcome $q^* = \frac{p^*}{1 - p^*}$ occurring is calculated by the expression

$$q^* = \frac{p_0}{1 - p_0} = \prod_{i=1}^{n} \frac{f_{1i}(p_i / q = 1)}{f_{0i}(p_i / q = 0)}, \tag{7}$$

where f_{1i} - assessment of the probability by the i-th expert under the condition of the implementation of the outcome

o_j; f_{0i} - assessment of the probability by the i-th expert under the condition of non-implementation of the outcome o_j.

There are many other methods for combining subjective probabilistic estimates. Due to space limitations of the article, these methods are not considered here.

Let us consider the possibility of combining subjective probabilistic estimates with possible objective values of these probabilities. Note, that the objective values of probabilities are not reliable enough to be used as basic estimates.

The idea of such a combination of probabilistic estimates obtained from various sources is presented in [17]. Let there be a complete system consisting of two random events. In the context of risk assessment, the first random event is the implementation of an outcome o_j with probability $p(o_j)$; the second random event is the non-implementation of the outcome o_j with probability $1-p(o_j)$. Uncertainty about a value $p(o_j)$ can be modelled using β distribution. In the general case, the density function of β distribution of a random variable X is represented by the expression

$$f(X)=\frac{(a+b+1)!x^a(1-x)^b}{a!b!}, \quad (8)$$

The expected value of the random variable X is

$$E(X)=\frac{a+1}{a+b+2}. \quad (9)$$

Let the expert subjectively assessed the probability of implementation of the outcome o_j as $p(o_j)=0.10$. Then, considering this probability as its expected value, we have

$$0.10=\frac{a+1}{a+b+2}. \quad (10)$$

The sum $(a+b)$ can be interpreted as the hypothetical number of attempts that were used to estimate the value of $p(o_j)$. Then a is interpreted as a hypothetical number of realizations of the outcome o_j in $(a+b)$ attempts. By assigning a hypothetical number of attempts $(a+b)$, the expert can express his degree of confidence in the value of $p(o_j)$. If the expert is not very confident in his estimate, a value of up to 10 can be assigned to $(a+b)$.

Let the expert subjectively estimate $a+b=8,\ a=1$. Then $b=7$.

Let us now assume that a computer simulation of the outcome o_j implementation process has been performed. As a result, it was obtained that the outcome o_j was realized once in 10 attempts.

Assuming that the conjugate posterior distribution for $p(o_j)$ is β distribution, the posterior value of probability $p^*(o_j)$ can be calculated by the expression

$$p^*(o_j)=\frac{m+a+1}{n+a+b+2}. \quad (11)$$

In our case, $m=1$, $n=10$. Substituting these values into expression (11), we have

$$p^*(o_j)=\frac{1+1+1}{10+1+7+2}=\frac{3}{20}=0.15. \quad (12)$$

This posterior value of the probability $p^*(o_j)=0.15$ seems to be more reliable than its prior value $p(o_j)=0.10$.

IV. Conclusions

Currently, expert estimates of probabilities are very widely used in various areas of human activity, including risk assessment. The prevalence of such assessments is evidenced by the fact that they are used in more than 80% of stochastic models in making strategic and tactical business decisions.

The importance of subjective assessments of probabilities in problems of risk assessment is evidenced by the fact that the costs in problems of subjective estimation in complex multidimensional studies range from $200,000 to $2 million [7].

In recent decades, effective approaches to the subjective estimation of probabilities have been proposed. Education and special training of experts is important for qualitative assessments. This makes it possible to obtain sufficiently reliable results even in very complex tasks of risk assessment.

This article is mainly of a review nature. It presents and analyses in a concise form the main elicitation method of subjective probabilistic estimates and methods for combining such estimates.

Directions for further research in this area are the analysis of existing approaches to evaluating probabilities using interval and fuzzy estimates in order to use them in specific risk assignment problems.

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Property Insurance Decision-making on the Basis of Utility Functions

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Abstract. **Property and other valuables insurance is widespread all over the world. An insurance company assumes the risk of damage or total destruction of the insured property. When this kind of damage or destruction is established, the company pays its client compensation (insurance premium) up to the amount specified in the insurance contract. For his part, the insured must pay a certain amount to the firm for the provision of insurance services. In any property insurance process, the question arises as to whether it is appropriate to insure the property for the price offered by the firm. The paper considers an approach to solving this problem based on expected utility theory.**

Keywords: Expected utility, insurance policy, insurance risks, risk attitude.

I. Introduction

The insurance industry is a powerful sector of financial operations in the world. Insurance companies offer insurance for property and health, industrial equipment of all kinds, vehicles and freight, passenger travel and flight safety, space launches, manned space flights, financial transactions, and much more.

There are two types of risk that must be considered in the insurance process. The first type describes the possible loss of the insured due to possible damage or total loss of their property. For the transfer of this type of risk to the insurance company, the insured pays a fee to the insurer. This payment is expressed in the form of the price of the insurance policy.

On the other hand, an insurance firm faces the risk of paying out large sums of money if its clients apply for insurance claims all at once. Insurance firms use proven methodologies to assess their risks and to price insurance policies for different insurance situations [1 - 6].

When deciding whether to insure their property, the insured must determine whether they are satisfied with the property insurance offered by the firm and the price of that insurance.

The simplest way to decide whether to insure a property is to compare the expected cash benefits with the price of the policy. However, in addition to the monetary value, the property may have an additional utility for the individual, which cannot always be expressed in terms of a simple monetary equivalent. Therefore, it is considered appropriate to value the insured property in terms of its usefulness to the individual.

The paper aims to demonstrate that expected utility theory can be used to make a decision about the purchase of property insurance policy. The task of the paper is to illustrate how a property insurance decision is made on the basis of the individual policy holder's utility function.

The method used in this paper is based on the use of reference lotteries to estimate the risk attitude of the insured. The analysis of insurance alternatives is the basis for making insurance decisions.

The paper examines an approach to property insurance based on the subjective utility function in expected utility theory.

II. A Brief Introduction to Expected Utility Theory

In 1738 D. Bernoulli put forward the ingenious idea that the utility of money does not increase in direct proportion to its quantity, but in a more complex way, namely as the logarithm of the quantity of money. Modern evidence shows that Bernoulli's conjecture of a logarithmic

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relationship between the utility of money and the quantity of money only occurs in certain specific situations.

Another important achievement of D. Bernoulli was the explicit notion that the utility of money depends not only on the additional amount of money, but also on the initial amount available to the individual.

Unfortunately, D. Bernoulli's fruitful ideas about utility have been forgotten for almost 200 years. A step in the direction of developing a grounded utility theory was the work of E. P. Ramsey [7] and B. de Finetti [8]. The first work that successfully laid the theoretical foundation for expected utility was the work of von Neumann J. and O. Morgenstern [9]. In this work, the authors proposed a system of axioms about an individual's preferences on a set of risky lotteries (games). They proved that by satisfying the requirements of these axioms, an individual's utility function can be constructed, and the best actions of an individual in risky choice situations are those that maximise the expected utility.

An essential feature of the von Neumann and Morgenstern approach was that the probabilities of relevant outcomes of lotteries (games) were assumed to be known and determined in an objective way. It is this approach that we use in the present paper.

In 1954, L. J. Savage [10] proposed another axiomatic basis for expected utility. In essence, Savage's approach is a synthesis of the ideas of de Finetti and von Neumann and Morgenstern. Its results consist in both a complete theory of subjective probabilities and a complete theory of expected utility.

Various aspects of the application of expected utility theory to insurance processes are discussed in [11 - 15]. Consider one important concept related to lotteries. The minimum fixed amount that is as attractive to an individual as participating in some lottery is called the deterministic equivalent of that lottery. The construction of an individual's utility function is based on his estimates of the deterministic equivalents of a sequence of lotteries given in the range of variation of some factor on which the utility function is defined. Money is most often used as such a factor.

The difference between the expected lottery winnings and the deterministic equivalent of that lottery for a particular individual is called the risk penalty, or risk premium. For risk-averse individuals, their risk penalty will always be positive. This paper assumes that all individuals making property insurance decisions are risk averse.

III. Analysis of the Properties of the Utility Function

Fig. 1 shows a graph of the conditional utility function, reflecting individual's perceptions of the utility of amounts of money in the range [0, 100] of conditional monetary units (c.u.). This graph reflects the subjective views of the risk-averse individual.

A basic property of any marginal utility function is that it reflects the relative reduction in utility as the value of the valuation criterion X increases. This property is visually illustrated in Fig. 1.

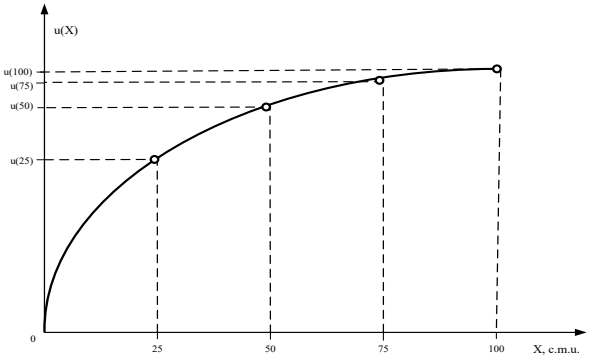


Fig. 1. Graph of the conditional utility function of the risk-averse individual.

On what factors does an individual's risk aversion in risky choice situations depend? Let us consider this problem in the context of expected utility theory using the example of choice in risky lotteries (games).

The main factors influencing the results of risky elections are:

- amplitude of variation of outcome estimates;
- probabilities of outcome estimates;
- the value of the rates when choosing in relation to an individual's available resources.

Let us analyse these factors in detail. Let us call an exact lottery (game) a lottery (game) that has two outcomes, the probability of each outcome being 0.5, and whose outcome estimates are equal in absolute value, but have opposite signs.

Suppose that the individual (the decision maker) has constructed his utility function on the set of some hypothetical sums of money X, whose graph is shown in Fig. 2. Suppose that an individual has a sum of money x_0 that constitutes his initial wealth. This individual is asked to choose between the following alternative actions:

1. To participate in the lottery L_1: $(a, 0.5; -a, 0.5)$;
2. To participate in the lottery L_2: $(2a, 0.5; -2a, 0.5)$;
3. To refuse to participate in both lotteries.

Suppose an individual decides to participate in the lottery L_1. Then on condition of winning, his current wealth will be equal to $x_0 + a$; on condition of losing, his current wealth will be equal to $x_0 - a$. If the individual decides to participate in the lottery L_2, his current wealth will be equal to either $x_0 + 2a$ or $x_0 - 2a$. The outcomes of both lotteries are shown on the horizontal axis X in Fig. 2. The vertical axis shows the values of the utility function corresponding to the reference value x_0 and the outcomes of both lotteries. Let us calculate the expected values of lotteries L_1 and L_2:

$$E(L_1) = 0.5(x_0 + a) + 0.5(x_0 - a) = x_0;$$
$$E(L_2) = 0.5(x_0 + 2a) + 0.5(x_0 - 2a) = x_0.$$

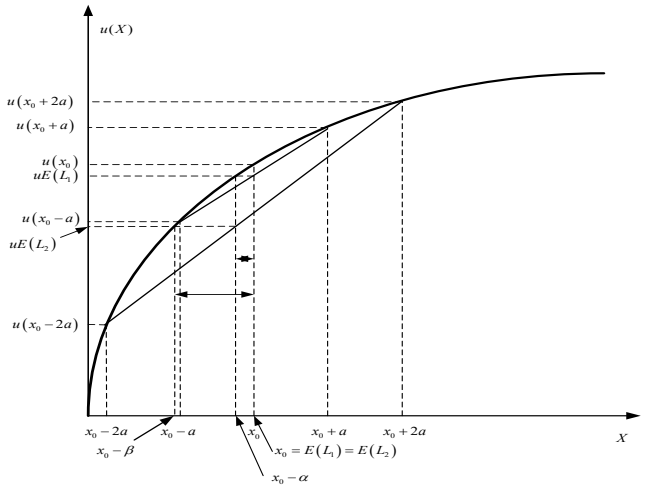


Fig. 2. An individual's utility function constructed for his cash and a reflection of two exact lotteries.

It is clear that in this situation the expected values of the lotteries cannot serve as a basis for choosing in favour of one of them.

The values of the expected utility for each of the lotteries can be calculated using the expressions (see Fig. 2)

$$Eu(L_1) = 0.5u(x_0 + a) + 0.5u(x_0 - a);$$
$$Eu(L_2) = 0.5u(x_0 + 2a) + 0.5u(x_0 - 2a).$$

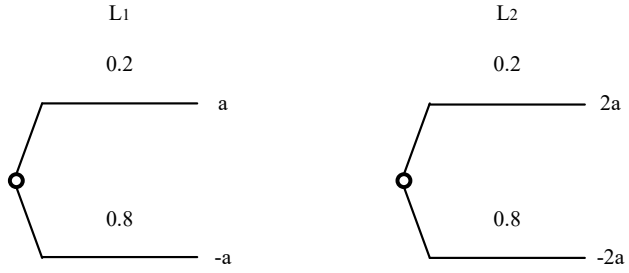
These expected utility values are shown on the vertical axis in Fig. 2.

Obviously, with this form of utility function (the individual is risk averse) $Eu(L_1) > Eu(L_2)$. This is explained as follows. The utility gain in the lottery L_1 on the interval $(x_0 + a)$ will be smaller than the utility loss on the interval $(x_0 - a)$ due to the property of relative utility loss with increasing values of X. This effect is even more pronounced in the lottery L_2 because of the larger scatter of the win/loss values relative to the reference value x_0.

In either case, the expected utility values of lotteries will be negative. Since the negative value $Eu(L_1)$ is less than the negative value $Eu(L_2)$, the individual should prefer participation in the lottery L_1 to the lottery L_2.

Not participating in lotteries leaves the individual with his or her own interests, because the expected utility of that action is 0. In general, risk increases when the amplitude of the variation in the estimates of outcomes in a risky lottery (game) increases.

Let us consider how the outcomes of risky choices can be affected by the probabilities of the outcomes. Let us turn to the lotteries discussed above. Suppose now that the lotteries are formulated as follows:



How would changing the probabilities of the outcomes affect the outcome of a choice between lotteries? Let us calculate the expected values of the lotteries.

$$E(L_1) = 0.2(x_0 + a) + 0.8(x_0 - a) = x_0 - 0.6a;$$
$$E(L_2) = 0.2(x_0 + 2a) + 0.8(x_0 - 2a) = x_0 - 1.2a.$$

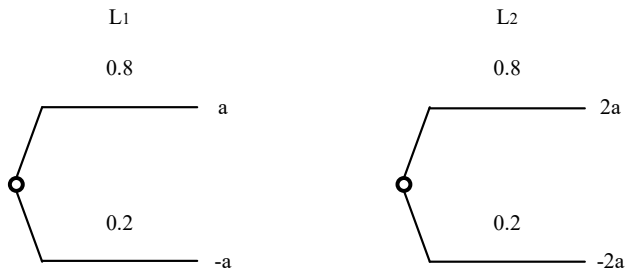
Even using the principle of maximisation of expected value and not involving the principle of maximisation of expected utility, we can confidently conclude that the lottery L_1 is preferable to the lottery L_2.

The expected utility values for these lotteries are calculated using the expressions

$$Eu(L_1) = 0.2u(x_0 + a) + 0.8u(x_0 - a)$$
$$Eu(L_2) = 0.2u(x_0 + 2a) + 0.8u(x_0 - 2a)$$

It is not difficult to show that the expected utilities of these lotteries are smaller than the expected utilities of the previously considered lotteries. This is because in the choice situation considered now, the utility values of the winnings are significantly reduced, but the utility values of the losses are significantly increased. As in the previous case, the lottery L_1 would be preferred to the lottery L_2. Now the utility of not participating in the lotteries has increased even more.

Let us consider another lottery option.



Let us calculate the expected values of the lotteries.

$$E(L_1) = 0.8(x_0 + a) + 0.2(x_0 - a) = x_0 + 0.6a;$$
$$E(L_2) = 0.8(x_0 + 2a) + 0.2(x_0 - 2a) = x_0 + 1.2a.$$

Using the criterion of maximising the expected value, it can be seen that the lottery L_2 is now preferred, and both lotteries are preferred over refusing to participate in them.

The expected utility values of these lotteries are calculated as follows:

$$Eu(L_1) = 0.8u(x_0 + a) + 0.2u(x_0 - a);$$

$$Eu(L_2) = 0.8u(x_0 + 2a) + 0.2u(x_0 - 2a).$$

Obviously, in this case $Eu(L_2) > Eu(L_1)$, from which it follows that participation in the lottery L_2 is preferable. It is also clear that under the criterion of maximising expected utility the least preferred option is not to participate in the lottery.

What general conclusion can be drawn from looking at these simple examples? The outcome of choices in risky situations will always be influenced by the probabilities of winning and losing. The greater the probabilities of winning (and therefore the lower the probabilities of losing), the more preferable the option becomes for the individual.

Consider the effect of initial wealth on an individual's (decision maker's) risk appetite. Fig. 2 shows two exact lotteries (games) for the initial wealth of the individual, valued by the sum of money x_0. Now suppose that the initial wealth is valued at $x_0' < x_0$. How will the individual's attitude to risk change in the situation of choosing on exact lotteries L_1', L_2', and the option of not participating in risky lotteries (games). If we plot the new choice situation in Fig. 2, it is obvious that the point x_0' will be to the left of the point x_0 on the horizontal axis. It is also obvious that the expected values of both lotteries will be equal to x_0', so that the criterion of maximising the expected value is useless in this new choice situation.

Given the property of the relative diminishing marginal utility, it can be argued that the utility reductions of lotteries L_1', L_2', will be even larger, since the point x_0' corresponds to a region of more rapid utility changes. Accordingly, the positive utility of the lotteries will also increase. But the overall effect of these changes would be to reduce the expected utility for both lotteries, with the greater utility reduction corresponding to the lottery L_2'. Therefore, as before, the lottery L_1' would be preferable to the lottery L_2', and not participating in both lotteries would be the most preferable course of action for the individual.

Now let the initial wealth of an individual, all other things being equal, be the sum of $x_0'' > x_0$ .This point will lie to the right of the point x_0 in Fig. 2. Obviously, now the changes in the utilities of the wins and losses in the new lotteries will be smaller than the changes in the corresponding utilities in the previous lotteries. This leads to a reduction in the expected utility of both lotteries. Although in this case the individual should prefer not to participate in both lotteries, however, the degree of this preference becomes smaller. It is quite possible that, if the value is large enough, the individual will agree to participate in one of the lotteries. This indicates his greater risk appetite in this choice situation.

How can the degree of risk aversion of a decision maker be formally assessed if his utility function on the set of values of the evaluation criterion X is constructed? To simplify things further, assume that X represents some amount of money that an individual has or could potentially have. This approach of reasoning on sums of money is prevalent in works on expected utility. The reason for this is the clear interpretability of the results achieved on hypothetical lotteries (games). The conclusions drawn from further analysis are fully transferable to any measurement scale of evaluation criterion X.

The most appropriate measure for formally assessing risk attitude is *the Arrow-Pratt absolute risk aversion measure*

$$r(X) = -\frac{u''(X)}{u'(X)}. \qquad (1, \text{a})$$

This expression is general in nature. If the evaluation is performed for a particular value $x_0 \in X$, expression (1, a) takes the form

$$r(x_0) = -\frac{u''(x_0)}{u'(x_0)}. \qquad (1, \text{b})$$

The second derivative $u''(x_0)$ characterises the degree of curvature of the utility function $u(X)$ at the point $x = x_0$. For the risk-averse decision maker, this derivative will always be negative at all points of definition of the function $u(X)$. The first derivative $u'(x_0)$ shows the slope of the function's $u(X)$ graph relative to the horizontal axis X at the point $x = x_0$. For a risk-averse decision maker, $u'(X)$ will be positive at all defining points of the function $u(X)$. To ensure that the values of $r(X)$ are always positive in expressions (1 a, b), the "-" sign is introduced. Higher values $r(X)$ correspond to lower risk aversion, and lower values $r(X)$ correspond to higher risk aversion.

IV. Making Decision to Insure Property

Let us consider solving this utility function problem using the following illustrative example. An individual's current wealth is valued at CU 100,000. This includes movable and immovable property and cash. The individual's immovable property is valued at 30,000 c.m.u. and the probability of losing it completely within the next year is estimated at 0.1. The individual wishes to insure the immovable property for an amount not exceeding 3,000 c.m.u. It must be verified whether this is the optimal solution, given that his utility function on the current

wealth is shown by the logarithmic function $u(X) = \ln(X)$.

Let us construct a graph of the individual's utility function. We do not need to construct this graph for the whole set X, it is enough to construct it only in the vicinity of the boundary amount of 100,000 c.m.u. A fragment of the graph is shown in Fig. 3.

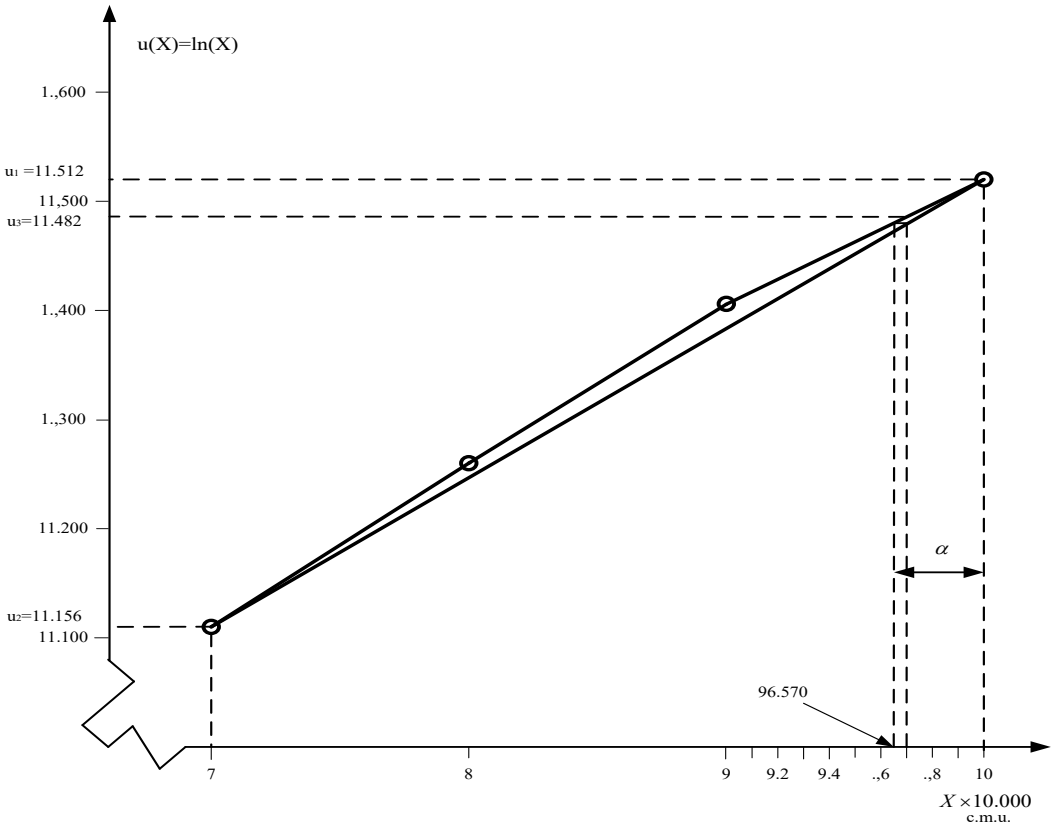


Fig. 3. Fragment of the utility function $u(X) = \ln X$ of an individual deciding to insure property.

$$\ln(100,000 - \alpha) = 11.478$$

Let us solve this equation relative to α

$$100,000 - \alpha = e^{11.478} = 96,567 .$$

$$\alpha = 100,000 - 96,567 = 3,432 \text{ c.m.u.}$$

From this it follows that if an insurance company offers to sell a property insurance policy for a price lower than 3,432 c.m.u., it is profitable for the individual to purchase the policy.

In this example, to ensure clarity and simplify calculations, we have used the utility function in logarithmic form $u(X) = \ln X$. In the case of an arbitrary form of the utility function graph, which is the case in most practical applications, the required utility values can simply be read from the graph.

V. Conclusion

To avoid the risks associated with damage or total destruction of property belonging to them, people take out insurance. The insurance company assumes the risk associated with the condition of the property during the insurance period and pays compensation in cases specified in the insurance contract.

When deciding on property insurance, the insurer must consider many factors including the importance of the insured property to the insured person, uncertainty about the possible future state of the property, as well as insurance costs (insurance contract price).

The use of a utility function constructed on the interval of the monetary equivalent of the relevant property allows us to explicitly represent the individual's subjective judgments about the utility of that property. If an individual has subjective judgements about the chances of damaging or losing a property in the future, the task of deciding whether to insure that property becomes trivial. Using the methodology presented in the previous section, an individual can estimate his financial possibilities associated with insurance, compare these possibilities with the price of the insurance policy, and on this basis make a final decision regarding insurance.

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Anomaly Detection - Review of Methods, Tools and Algorithms

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This paper contains review of algorithms, methods and tools nowadays used for anomaly detection.

Anomaly detection is used in many domains of science and industry, some authors classify anomaly detection as data mining and data science tool, others state it is decision support tool under artificial intelligence domain and indeed the use cases of anomaly detection are very different.

The article describes the main algorithms used for anomaly detection from perspective of theory of computer science and practical use cases of anomaly detection in different domains of industry. Several paragraphs are dedicated to the frameworks used by one of the most popular and powerful anomaly detection tools available in the market - Microsoft Anomaly detector.

Keywords: Algorithms, Anomaly detection, Novelty detection, Outlier detection.

I. INTRODUCTION

Anomaly detection refers to the problem of finding patterns in data that do not conform to the expected behaviour. These non-conforming patterns are often referred to as anomalies, outliers, discordant observations, exceptions, aberrations, surprises, peculiarities or contaminants in different application domains [1].

Anomaly detection is used in many areas:

- Financial fraud detection [2].
- Anti-money laundering [3].
- Disease detection.
- Network security threat detection.
- Detection of anomalies in the logs of software.
- Monitoring of nature, weather or climate change.
- Monitoring of industrial equipment faults.
- Defect detection.
- Detecting faulty products from vision sensors [4].
- Traffic prediction [5].

In this article methods and tools used during anomaly detection will be described for different use case scenarios.

Purposes and goals of usage of anomaly detection could be:

- **Product performance:** An anomaly detection paired with machine learning can correlate the existing data to be cross-checked while maintaining generalization and finding odd standing products with complete knowledge of what makes them an anomaly [6].
- **Technical performance:** For example, any faults in your own deployed system may leave your server to be vulnerable to active DDoS attacks. Such errors can also be proactively avoided and treated at the root using machine learning integrated into the DevOps pipeline [6].
- **Training performance:** During the pre-training phase, anomaly detection can come in handy, pointing out irregularities in the data set, which may cause the model to over-fit and, in turn, act poorly [6].

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Anomalies could be recognized by:

- **Statistical analysis:** By calculating measures such as mean, median, and standard deviation, you can identify data points significantly different from the rest of the sample [5].
- **Machine learning algorithms:** Various machine learning algorithms can be used to identify anomalies, such as clustering, classification, and density-based methods [5].
- **Data visualization:** By creating charts or plots of your data, you can visually identify anomalies by looking for points or trends that stand out [5].
- **Rule based systems:** You can set up rules or thresholds to flag data points that fall outside a specific range or violate certain conditions [5].
- **Human inspection:** In some cases, manually reviewing the data may be necessary to identify anomalies that may not be easily detected through automated methods [5].

Anomalies could be further classified on the way the data of anomalies differ from normal data:

- **Outliers:** Short/small anomalous patterns that appear in a non-systematic way in data collection [7].
- **Change in Events:** Systematic or sudden change from the previous normal behaviour [7].
- **Drifts:** Slow, unidirectional, long-term change in the data [7].

Anomaly classification from data perspective "with real world context":

- **Point Anomaly:** A tuple within the data set that can be an anomaly if it is far from the trend set by the other data points [6].
- **Contextual Anomaly:** Contextual anomalies can be considered an anomaly only if taken in a particular context and may even be valid if taken from another context [6].
- **Collective Anomaly:** Such anomalies occur when data points in a whole collection of points act strange towards the other values, making the subset a complete rarity [6].

Data of anomalies are usually interesting for further studies, but sometimes anomaly detection methods and tools are used to remove the "noisy" data from the data set before the further analysis. This might be in the case when sensor data return anomalies due to broken or malfunctioning sensors.

Natural sciences with anomaly detection tasks work in different ways. In the scope of this work we focus on anomaly processing with methods and tools available in mathematics, algorithms and artificial intelligence rather than physics which tend to improve measurement results from sensors by combining sensor data to reduce the number of anomalies in final calculated sensor measurements.

For example, satellites can have many sensors to monitor climate change on the earth, but some particular measurement could be done only by combining data from many sensors, reducing the noise, removing anomalies, removing data which are not correct due to bad visibility (clouds, fog, etc.).

More on remote sensing and satellite data processing one can find in the research aimed to develop a split-window (SW) algorithm to estimate land surface temperature (LST) from two-channel thermal infrared (TIR) and one-channel middle infrared (MIR) images of SLSTR observation [8].

II. Materials and Methods

Anomaly Detection in Machine Learning (ML) is the complete procedure of dealing with anomalies and irregularities in a data set. These can either be outliers or data points significantly different from the usual trend that the other data points follow. These irregularities tend to become an issue while training causing unwanted skewing in the model predictions [6].

Benefits and importance of machine learning in anomaly detection:

- **It makes scaling anomaly detection easier:** by automating the identification of patterns and anomalies without requiring explicit programming [9].
- **Highly adaptable:** Machine Learning algorithms are highly adaptable to changing data set patterns, making them highly efficient and robust with time [9].
- **Easily handles large and complex data sets:** making anomaly detection efficient despite the data set complexity [9].
- **Ensures early anomaly identification and detection:** by identifying anomalies as they happen, saving time and resources [9].
- **Higher levels of accuracy:** Machine Learning based anomaly detection systems help to achieve higher levels of accuracy in anomaly detection compared to traditional methods [9].

Anomaly Detection in machine learning, either pre-model or post-model development and deployment, is an essential task to ensure the smooth running of the ML operations pipeline. With small, skewed values in the data pre-training or frauds and misuse of your services, anomaly detection goes a long way to cut cost, time and boost performance [6].

In Layman's terms, Anomaly Detection is ultimately the task of training a machine to gauge the ability to define what is expected. Still, when paired with machine learning, it also ensures that the model does not lose its ability to generalize [6].

From machine learning techniques which we can use for anomaly detection we can mention:

- **Normal-only anomaly detection:** Several approaches to designing anomaly detection algorithms require little or no anomalous data. These "normal-only" methods train an algorithm on normal data only, and identify data outside those norms as anomalous [10].
- **Unsupervised learning:** In addition to the unsupervised learning techniques, i.e., K-means, Gaussian mixture techniques, K-medians, etc., Anomaly Detection for unsupervised learning also deals with unlabelled data - anomaly detection for such knowledge also works by figuring out the pattern the unlabelled points are following. A vast selection of unsupervised learning algorithms works on the concept of clustering techniques [6].
- **Isolation forest:** The premise of the Isolation Forest algorithm is that anomalous data points are easier to separate from the rest of the sample.

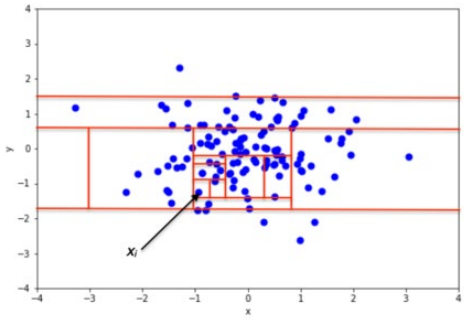

Fig. 1. Isolation of non-anomalous data point [11]

In order to isolate a data point, the algorithm recursively generates partitions on the sample by randomly selecting an attribute and then randomly selecting a split value between the minimum and maximum values allowed for that attribute [11].

In the example, "Fig. 1.", we see isolation of non-anomalous data point [11]. In the example, "Fig. 2.", we see the isolation of anomalous data point [11].

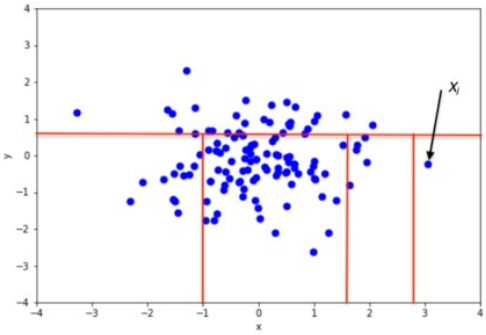

Fig. 2. Isolation of anomalous data point [11]

- **Mahalanobis Distance:** In statistics, we sometimes measure "nearness" or "farness" in terms of the scale of the data. Often "scale" means "standard deviation". For uni-variate data, we say that an observation that is one standard deviation from the mean is closer to the mean than an observation that is three standard deviations away. For many distributions, such as the normal distribution, this choice of scale also makes a statement about probability. Specifically, it is more likely to observe an observation that is about one standard deviation from the mean than it is to observe one that is several standard deviations away [12]. Mahalanobis Distance is a multi-dimensional generalization of the idea of measuring how many standard deviations away P is from the mean of D. This distance is zero for P at the mean of D and grows as P moves away from the mean along each principal component axis. If each of these axes is re-scaled to have unit variance, then the Mahalanobis distance corresponds to standard Euclidean distance in the transformed space. The Mahalanobis distance is thus unit-less, scale-invariant, and considers the correlations of the data set [13].
- **Autoencoders:** This approach uses artificial neural networks to compress the data into lower dimensions in order to encode it. The data is then decoded by ANNs to recreate the initial input. The rules are already recognized in the compressed data, so when we lower the dimensionality, we don't lose the necessary information [14].

Machines cannot learn a function that translates input features to outputs using unsupervised machine learning because they lack examples of input-output pairings. Instead, they discover structure within the input features and use that to learn. Unsupervised methods are more widely used in the field of anomaly identification than supervised ones because, as was already said, labelled anomalous data is comparatively uncommon. However, the type of anomalies one expects to find is frequently very particular. As a result, many of the abnormalities discovered in an entirely unsupervised approach may simply be noise and may not be relevant to the task at hand [14].

- **Supervised learning:** Since supervised learning relies on labelled data, so do the techniques used to detect anomalies in such models. However, detecting anomalies in such labelled data can be much easier than doing so in unsupervised learning data sets; these techniques hold great potential to be automated and made more efficient [6]. Machines learn a function that maps input features to outputs based on sample input-output pairings while they are learning under supervision. Adopting application-specific knowledge into the process of anomaly detection is the aim of supervised anomaly detection algorithms [14].
- **Support Vector Machines:** Another supervised machine learning approach that is frequently used

for classification is the support vector machine (SVM). SVMs categorize data points using hyper-planes in multidimensional space. The threshold for outliers that must be manually selected is the hyper-parameter [14].

- **K Nearest Neighbours:** A popular supervised machine learning approach for classification is kNN. KNN is a helpful tool when used to solve anomaly detection difficulties since it makes it simple to see the data points on the scatter-plot and makes anomaly identification much more understandable. The fact that kNN performs well on both small and large data sets is an additional advantage. In order to tackle the categorization problem, kNN doesn't actually learn any 'normal' and 'abnormal' values. Therefore, kNN functions as an unsupervised machine learning method for anomaly detection. A range of normal and abnormal values is explicitly defined by a machine learning expert, and the algorithm automatically divides this representation into classes [14].
- **Semi-supervised learning:** It is a blend of the supervised and unsupervised learning, typically, it occurs when there are marked input data but no identified outliers. The model will learn the trends of the standard data from the labelled training data and find anomalies in the unlabelled data that exceed this threshold [6]. Semi-supervised machine learning strategies use a variety of techniques that can benefit from both huge volumes of unlabelled data and sparsely labelled data, acting as a type of middle ground. Due to the abundance of normal instances from which to learn and the dearth of examples of the more unusual or abnormal classes of interest, many real-world anomaly detections use cases are well suited to semi-supervised machine learning. One can train a reliable model on an unlabelled data set and assess its performance using a small quantity of labelled data on the presumption that the majority of the data points in an unlabelled data set are normal [14].
- **Local outlier factor (LOF):** The most popular method for anomaly identification is likely the local outlier factor. The idea of local density serves as the foundation for this method. It contrasts an object's local density with the densities of the nearby data points. A data point is deemed an outlier if its density is lower than that of its neighbours [14]. The local outlier factor is based on a concept of a local density, where locality is given by k nearest neighbours, whose distance is used to estimate the density [15].
- **Robust Covariance:** For gaussian independent features, simple statistical techniques can be employed to detect anomalies in the dataset. For a gaussian/normal distribution, the data points lying away from 3rd deviation can be considered as anomalies. For a dataset having all the feature gaussian in nature, then the statistical approach can be generalized by defining an elliptical hypersphere that covers most of the regular data points, and the data points that lie away from the hypersphere can be considered as anomalies [7].
- **DBSCAN:** This approach uses unsupervised machine learning and is based on the density principle. By examining the local density of the data points, DBSCAN may find clusters in sizable spatial data sets and generally produces positive findings when used for anomaly identification [14].

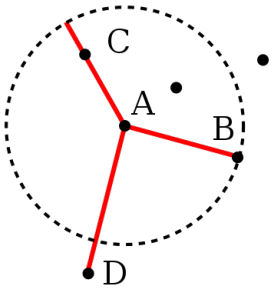

Fig. 3. Reachability distance [15]

- **Bayesian networks:** Machine learning engineers may find anomalies even in high dimensional data thanks to Bayesian networks. When the anomalies we're seeking are subtler and challenging to spot and visualizing them on the plot might not yield the expected results, we employ this strategy [14].

Depending on the availability of the type of data — negative (normal) vs. positive (anomalous) and the availability of their labels — the task of AD involves different challenges [16].

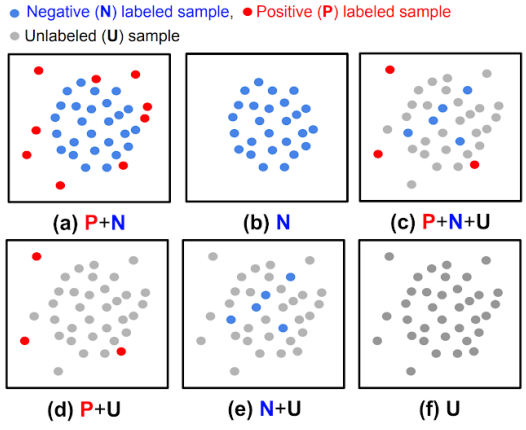

Fig. 4. Labelled data anomaly detection [16]

While most previous works were shown to be effective for cases with fully-labelled data (either (a) or (b) in the above figure), such settings are less common in practice because labels are particularly tedious to obtain. In most scenarios users have a limited labelling budget, and sometimes there are not even any labelled samples during training. Furthermore, even when labelled data are available, there could be biases in the way samples are labelled, causing distribution differences. Such real-world

data challenges limit the achievable accuracy of prior methods in detecting anomalies [16].

As well to many algorithms one can find for anomaly detection, there exist methods to estimate the performance of each algorithm and usability of algorithms for some particular task.

NAB is a standard open-source framework for evaluating real-time anomaly detection algorithms. In simple words, it is a repository that you can easily find on Kaggle. NAB consists of two main components: a dataset containing labelled real-world time series data and a scoring system designed for streaming data. The dataset contains 58 labelled files (approximately 365,000 data points) from various sources such as IT, industrial machine sensors, and social media [5].

A. Anomaly detection in Microsoft Azure cloud "Cognitive services"

In next sections the relationship of modern framework of anomaly detection tool which is part of Cognitive Services (Microsoft AI solution in Azure cloud) and machine learning will be described.

Anomaly detection finds application in many domains including cyber-security, medicine, machine vision, statistics, neuroscience, law enforcement and financial fraud to name only a few. Anomalies were initially searched for clear rejection or omission from the data to aid statistical analysis, for example to compute the mean or standard deviation. They were also removed to better predictions from models such as linear regression, and more recently their removal aids the performance of machine learning algorithms. However, in many applications anomalies themselves are of interest and are the observations most desirous in the entire data set, which need to be identified and separated from noise or irrelevant outliers [17].

Azure Cognitive Services are AI solutions available in Microsoft Azure Cloud. Cognitive Services allow application developers to use those via API calls and hide the complexity of AI algorithms. Developers are able to use AI solutions in their applications in a standard way designed by Microsoft as software vendor and focus on business logic automation tasks instead.

Azure Cognitive Services provide solutions in following AI domains [18]:

- Speech:
- Speech to text;
- Text to speech;
- Speech translation;
- Speaker recognition;
- Language:
- Entity recognition;
- Sentiment analysis;
- Question answering;
- Conversational language understanding;
- Vision:
- Computer vision;
- Custom vision;
- Face API;
- Decision:
- **Anomaly detector;**
- Content moderator;
- Personalizer;
- Open AI service.

As we see “Anomaly detector” goes under AI services which support decision making.

In mathematics, a time series is a series of data points indexed (or listed or graphed) in time order. Most commonly, a time series is a sequence taken at successive equally spaced points in time. Thus, it is a sequence of discrete-time data. Examples of time series are heights of ocean tides, counts of sunspots, and the daily closing value of the Dow Jones Industrial Average [19].

Time series analysis comprises methods for analysing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model to predict future values based on previously observed values [19].

Anomaly detector service helps to detect anomalies in:

- uni-variate time series data;
- multivariate time series data.

As for all the other Cognitive Services the complexity and all the algorithms used to detect anomalies are hidden from developers. Developers can use API calls towards the solution and get the results from it.

In “Fig. 5” one can see an example of uni-variate time series graphical representation [18].

According to Microsoft documentation machine learning algorithms are used only when working with multivariate time series. For uni-variate time series Anomaly detector is processing using many different algorithms and mathematical methods which could be a part of processing multivariate time series as well.

Tony Xing describes the algorithms used in uni-variate anomaly detection process: “State of art anomaly detection system often uses a one size fit all approach. Which mean they apply some specific algorithm on all types of time series. Our learning is that each algorithm can handle some specific type of time series better. Our innovation is that we

provide a generic framework to plug in different algorithm ensembles to handle a wide spectrum of different time series [20].

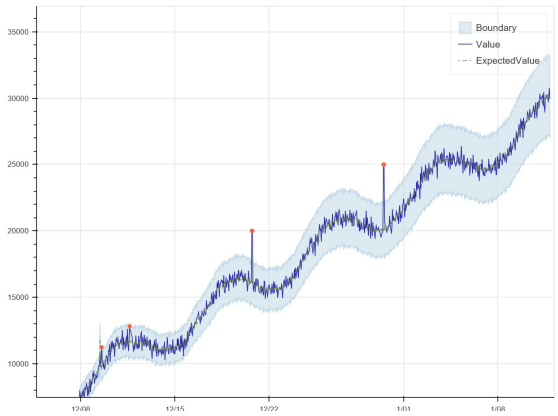

Fig. 5. Example of univariate time series [18]

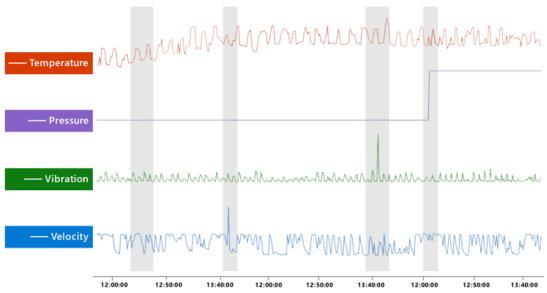

Fig. 6. Example of multi-variate time series [18]

In our different ensembles, we have following algorithms used [20]:

- Fourier Transformation;
- Extreme Studentized Deviate (ESD);
- STL Decomposition;
- Dynamic Threshold;
- Z-score detector;
- SR-CNN.

In "Fig. 7. and Fig. 8." one can see algorithm selection process for uni-variate time-series [20]:

Detecting all kinds of anomalies through one single endpoint "Fig. 9." [20]:

Besides spikes and dips, Anomaly detector also detects many other kinds of anomalies, such as trend change and off-cycle softness, all in one single API endpoint.

Microsoft Anomaly detector is available in Microsoft Azure cloud. It has API for such programming languages as Python, C sharp, etc. If organization plans to use Microsoft Azure cloud and build solutions using Anomaly detector, first it has to check availability of Anomaly detector in particular region of the Microsoft Azure cloud [21].

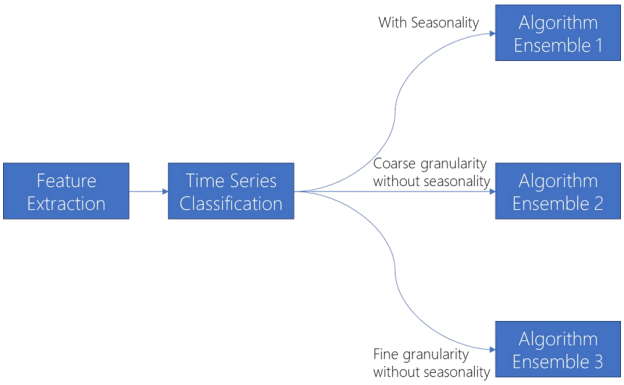

Fig. 7. Algorithm selection process for univariate timeseries [20]

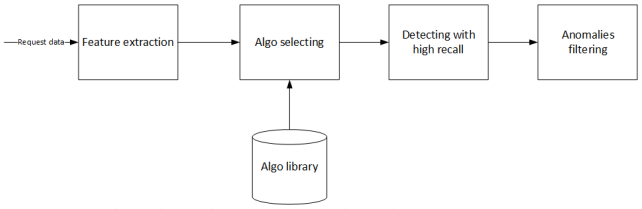

Fig. 8. Algorithm selection process for univariate timeseries [20]

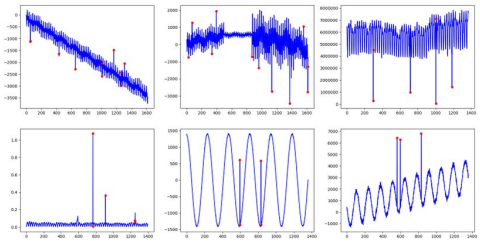

Fig. 9. Detecting all kinds of anomalies in univariate timeseries [18]

Recently Microsoft has released the graphical representation "Fig. 10." of the framework which they do use in the process of multivariate anomaly detection. It was done by one of Anomaly detector project leaders via blog [22]. This is not the part of Anomaly detector documentation it is rather as description of the framework for customers and explanation on how the results are achieved.

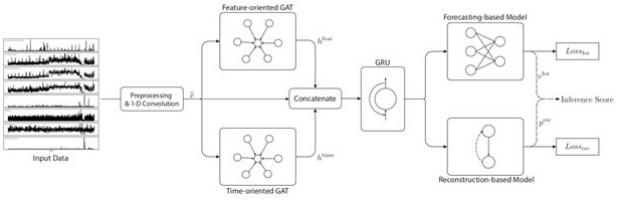

Fig. 10. Detecting anomalies in multi-variate timeseries [22]

Tony Xing describes the multivariate anomaly detection process: "In this newly introduced feature, we productized a novel framework - MTAD-GAT (Multivariate Time-series Anomaly Detection via Graph Attention Network), to tackle the limitations of previous solutions. Our method considers each univariate time-series as an individual feature and tries to model the correlations between different features explicitly, while the temporal dependencies within each time-series are modelled at the same time. The key ingredients in our model are two graph attention layers, namely the feature-oriented graph attention layer and the time-oriented graph attention layer. The feature-oriented graph attention layer captures the causal relationships between multiple features, and the time-oriented graph attention layer underlines the dependencies along the temporal dimension. In addition, we jointly train a forecasting-based model and a reconstruction-based model for better representations of time-series data. The two models can be optimized simultaneously by a joint objective function [22].

Graph Attention Networks is a subclass of Graph Neural Networks first presented to wider audience as a conference paper at ICLR 2018 (Sixth International Conference on Learning Representations, Vancouver Convention Center, Vancouver CANADA) [23].

From the above we can conclude that Anomaly detector in Microsoft cognitive services is built upon ideas from the latest scientific discoveries. When we see the API documentation we can notice that many parts of API are still developed further and documentation has the warning that API may change in the future.

The idea is that for GANs during matrix computations behind the scenes the weight of attention is calculated for a node on how much it should consider other nodes in the neighbourhood during the decision-making process and that is used as learning mechanism. Weights could change during the calculation process as new information comes from the neighbourhood.

III. Results and discussion

Anomaly detection is data processing challenge in different areas of natural sciences where results of research depend on data collection from sensors, databases, etc. Anomalies can be present in any data and could correspond to the data facts that scientists are interested into or could be the noise in data scientists would like to exclude from their processing and further analysis. The anomaly detection field in science is wide so in next section we will look into some anomaly detection real life usage scenarios.

A. Anomaly detection use case scenarios

In the real world, popular anomaly detection applications in deep learning include detecting spam or fraudulent bank transactions. Systems are already in place in most major banks where the authorities are alerted when unusually high spending or credit activity occurs on someone's account. The term "unusually high" can be defined on a user-to-user basis or collectively based on account type [24].

In industries, anomaly detection applications attached with machinery can help flag irregular or dangerous temperature levels or movement in parts or filter faulty materials (like filtering strange-looking food ingredients before they are processed and packed). Given that data can back the decision and sufficiently reliable data is available, anomaly detection can be potentially life-saving [24].

In a different use case, anomaly detection machine learning algorithms can also be used for classification tasks when the class imbalance in the training data is high. For instance, one can gather images of various species of flowers and plants for a multi-class classification task. However, substantially insufficient data is likely available for one particular species, thus resulting in an imbalance in the dataset. In such a case, the model can treat that class as an anomaly and classify the species differently. This is particularly relevant for medical diagnosis where there are only a few samples (images or test reports) where the disease is present, with the majority being benign. Anomaly detection can again be a life-saver in these cases [24].

HSBC, one of the largest banks in the world (more than 38 million customers), uses anomaly detection to deal with anti-money laundering (AML) issues. HSBC representative says: "It's a game changer because it's something we can scale when you operate in more than 60 jurisdictions. It will enable us to have consistency in how we do anti-money laundering" [3]. The bank said it would have an estimated 100 petabytes of data on Google Cloud by the end of 2018.

We can read about usage of anomaly detection for production line failure prediction in following paper [25]. As One of the main challenges here is mentioned that usually one production line could be used for production of many items based on the predefined input parameters. As production line could be changed by input parameters so the results of the sensor measurements do change when the input parameters are changed and this requires special learning cycle for anomaly detection for each product production line can produce.

Another example of anomaly detection is mentioned in article [26], where scientists review satellite data and anomalies in satellite data to correctly estimate biodiversity and other ecological factors of National forests in United States.

In article [27] Google historical stock data analysis is described with the help of Python library Scikit-learn [28].

With these examples we have covered just a small amount of use cases of anomaly detection and there is a space for further studies and further use case scenarios using different methods, tools and algorithms.

Author of this article plans to continue his further research in anomaly detection by finding solutions for different use case scenarios with the help of existing

anomaly detection tools available in the market, for example, Microsoft Anomaly detector.

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EDUCATION IN ENGINEERING SCIENCES

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Application of the Finite Element Method for the Design of Small Arm Barrels

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Abstract. **The article presents an experimental investigation of the possibility for using the finite elements method (FEM) for definite the frequency of cross vibrations to the barrel of the small arm. To achieve the goals of the investigation a model of a real barrel with software product based on the method of the final elements is created. An experimental investigation with real shooting is done and statistics hypothesis checking is executed.**

Keywords: barrel vibrations, small arms, finite element method, grouping of hits.

I. INTRODUCTION

In the last decade other countries have made research about increasing effectiveness on the battle weapons, they have proved the big effect from the transversal vibrations on the barrel to the group and the accuracy on the target. The transversal vibrations are turned to be one of the main reasons for reducing the accuracy of the shooting, because of sagging the barrel in the horizontal and vertical level, and for reducing the grouping, because the bullets get out of the barrel in a different stage of the movement of the muzzle part.

In Republic of Bulgaria this kind of research haven't been made yet and that why in this document it is investigated the possibility of using the method of ending elements for determination the frequency of self-transversal vibrations on the barrel of the shooting weapons.

For determination the frequency of self-transversal vibrations, the barrel is accepting for a pole with complex section, stably attached on the one end and free from the other.

The existing similar models for determination the frequency of self-transversal vibrations on the barrel of the battle weapons have these following disadvantages:

- their formulas are applicable only for cylindrical or tapered barrels and they can't be used for barrels with complex form;
- the models don't offer formulas for determination the frequency of self-transversal vibrations on the barrel in presence of added mass lying on it;
- the target that is placed on that research is to verify convergence of results from frequency of self-transversal of barrel of small arms, the results from using the method of the final elements and the results from the experimental shootings.

II. RESEARCH

The main purpose of the present study is to verify whether the finite element method is applicable for determining the frequencies of the natural transverse oscillations of the small arms barrel.

The tasks of research are:

- creating a model of a real barrel with software product based on the method of the final elements and the frequency of self-transversal vibrations of the barrel;
- conduction of experimental shootings and the frequency of self-transversal vibrations of the barrel;
- processing the results and assess the adequacy of the model.

True the researching is imputed the following restriction: it is explored only the secondary frequency of self-transversal vibrations, influencing the grouping on semi-fire.

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The creating of three-dimensional model on the barrel is realized with the program SOLD EDGE ST3, for base is used a real existing ballistic barrel, designed for rounds 7,62x54 model 908/30 year.

On the program NX 7.5 NASRAN is committed the separation of the three-dimensional model of the barrel in elements. For barrel, designed round model 908/30 year, are used 10-point elements with length cathetus 8 mm. The total number of the elements is 7233, and for the points are 13715. For the add weights are used 10 points elements with length cathetus 2 mm, there for the number of elements and the points are as it follows: for weight with mass 0,027 kg - 3612 elements and 7356 points: for weight with mass 0,054 kg - 6476 elements and 11462 points, for weight with mass 0,081 kg - 9455 elements and 15796 points. For weight with mass 0,105 kg - 11398 elements and 18640 points. For weight with mass 0,204 kg - 20700 elements and 32112 points. For weight with mass 0,303 kg - 29752 elements and 45125 points. For weight with mass 0,406 kg -44758 elements and 66867 points. For weight with mass 0,506 kg - 51673 elements and 76738 points.

For the analysis of the barrel is used steel mark 50 Pa with the following characteristics: flexural modulus - 2,16.105 MPa; density of the material - 7840 kg/m3; yield strength - 748 MPa; ultimate tensile strength - 980 MPa.

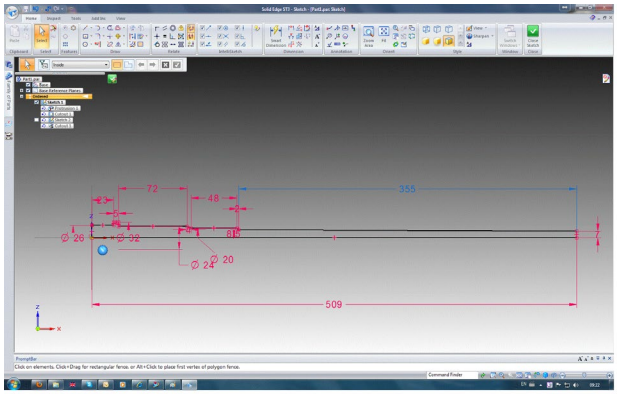

Fig. 1. Barrel draft.

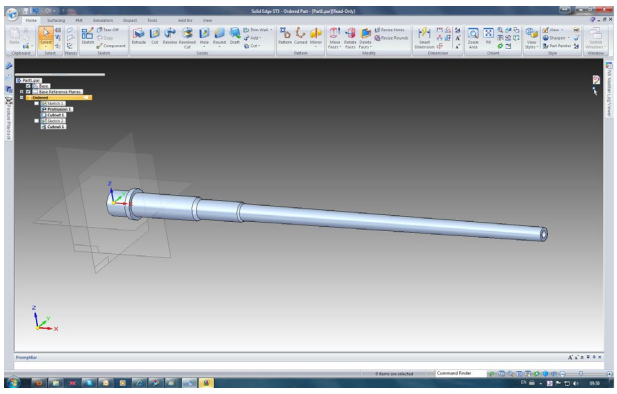

Fig. 2. Ballistic barrel three-dimensional model.

For the weights used steel 45 with the following characteristics: modulus of elasticity – 2,0694. 105 MPa; density of the material - 7829 kg / m3; yield strength - 129,5 MPa; ultimate tensile strength - 262 MPa. Data on the barrel: weight - 0,951kg; length to the point of attachment - 0,486 m; outside diameter at the point of attachment - 0,024 m; inner diameter of the channel - 0,00762 m. For maximum pressure in the barrel channel is accepted value Pmax. cp = 2900 kg/cm^2.

Place the maximum pressure is 448 mm from muzzle cut. The attachment of weight to barrel is carried out in four points, which corresponds to the actual attachment. Calculations were performed with real tables with weights placed sensor that: 0,027 kg, 0,054 kg, 0,081 kg, 0,105 kg, 0,204 kg, 0,303 kg, 0,406 kg, 0,506 kg.

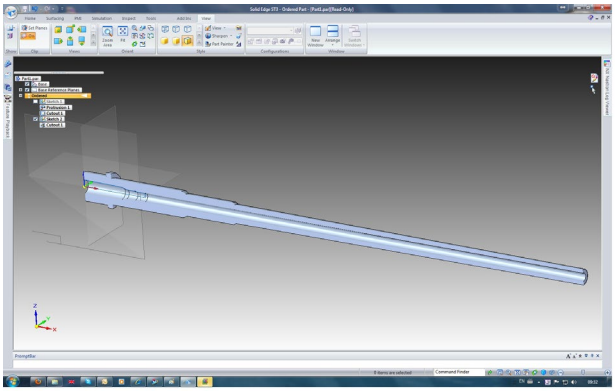

Fig. 3. Incision of ballistic barrel.

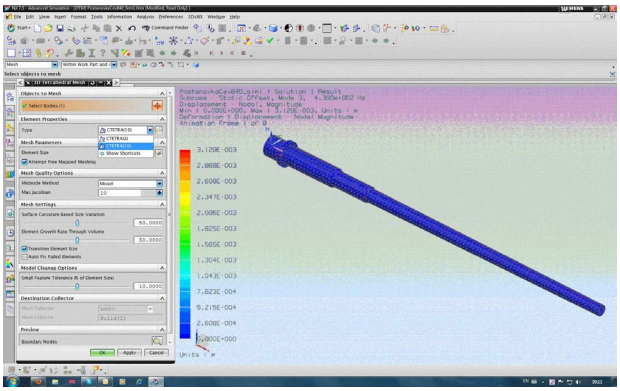

Fig. 4. Three-dimensional model of the barrel using 1908/30 cartridges, broken down into parts.

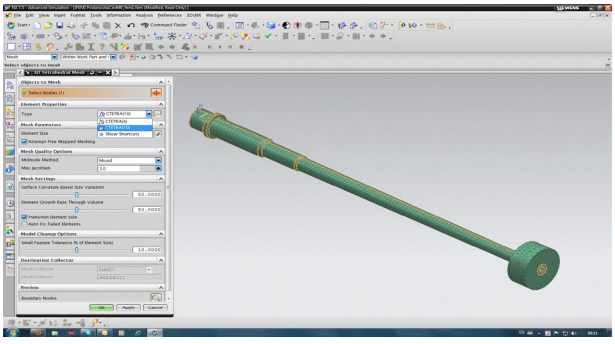

Fig. 5. Three-dimensional model of the barrel, using cartridges model 908/30, broken into elements, with a weight of mass 0.406 kg placed on its end.

The experimental study was performed in an indoor shooting tunnel in the workshop "Small and anti-aircraft weapons" in Central artillery technical testing ground (military unit 26940 - Stara Zagora). FIG. 6 is a schematic of the deployment of the equipment used to conduct the experimental shooting.

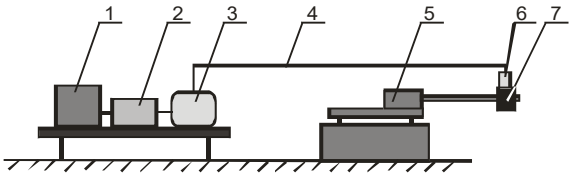

Fig. 6. Scheme of experimental investigation devices disposal. 1- computer (program "Lab View 8.5"); 2- DAQ - measurements plate NI USB-6211 – National Instruments; 3- measurements amplifier Type 2635 – Brüel & Kjær; 4- cable; 5- base for ballistic barrel; 6- censor for vibrations measurement.

Fig. 7. Base for ballistic barrel.

Fig. 8. Masses that were mounted on barrel edge with values 0,025; 0,05; 0,075; 0,100; 0,125, 0,150; 0,175; 0,200; 0,225; 0,250; 0,275; 0,300 kg.

Results from a theoretical study, done using a computer model and experimental study are presented in Table 1 and FIG. 9.

TABLE 1 RESULTS OBTAINED FROM THE COMPUTER MODEL AND THE EXPERIMENTAL STUDY OF THE SECOND FREQUENCY OSCILLATIONS OWN CROSS BALLISTIC BARREL, DESIGNED FOR CARTRIDGES 7,62x54 MODEL 908/30.

Distance from end of barrel to the mass [m]	*Results of the experiment*	*Results of the computer model*		*Results of the experiment examination*	*Results of the computer model*	
	Second frequency [Hz]	*Second frequency [Hz]*	*Relatively mistake [%]*	*Second frequency [Hz]*	*Second frequency [Hz]*	*Relatively mistake [%]*
Mass of added weight on barrel – 0,00 [kg]						
0	428	449	-4.906			
Mass of added weight on barrel 0,027 [kg]				**Mass of added weight on barrel 0,054 [kg]**		
0	388	401	-3.351	376	391	-3.99
0,01	392	415	-5.873	382	400	-4.71
0,02	396	421	-6.313	388	409	-5.41
0,03	400	426	-6.5	392	417	-6.38
0,04	404	430	-6.436	398	423	-6.28
0,05	405	433	-6.914	402	429	-6.72
0,06	406	436	-7.389	404	433	-7.18
0,07	407	438	-7.617	406	436	-7.39
0,08	408	439	-7.598	407	437	-7.37
0,09	408	439	-7.598	408	438	-7.35
0,10	408	438	-7.353	408	437	-7.11
0,11	407	437	-7.371	407	434	-6.63
0,12	406	435	-7.143	406	431	-6.16
Mass of added weight on barrel 0,081 [kg]				Mass of added weight on barrel 0,105 [kg]		
0	368	379	-2.989	364	371	-1.92
0,01	374	390	-4.278	370	383	-3.51
0,02	382	400	-4.712	378	394	-4.23
0,03	388	410	-5.670	386	405	-4.92
0,04	392	418	-6.633	392	414	-5.61
0,05	396	426	-7.576	396	423	-6.82
0,06	402	432	-7.463	400	429	-7.25
0,07	402	436	-8.458	401	434	-8.23
0,08	406	437	-7.636	402	437	-8.71
0,09	407	437	-7.371	404	437	-8.17
0,10	407	436	-7.125	406	435	-7.14
0,11	406	435	-7.143	405	439	-8.40
0,12	405	428	-5.679	404	429	-6.19
Mass of added weight on barrel 0,204 [kg]				**Mass of added weight on barrel 0,303 [kg]**		
0	350	352	-0.571	344	341	0.872
0,01	360	365	-1.389	352	355	-0.85
0,02	366	378	-3.279	360	369	-2.50
0,03	376	391	-3.989	374	382	-2.14
0,04	380	403	-6.053	378	395	-4.50
0,05	388	414	-6.70	390	406	-4.10
0,06	396	423	-6.818	400	416	-4.00
0,07	400	429	-7.25	404	423	-4.70
0,08	404	432	-6.93	408	428	-4.90
0,09	408	433	-6.127	406	428	-5.42
0,10	407	430	-5.651	403	424	-5.21
0,11	406	423	-4.187	402	417	-3.73
0,12	404	417	-3.218	400	406	-1.50
Mass of added weight on barrel 0,406 [kg]				**Mass of added weight on barrel 0,506 [kg]**		
0	338	334	1.183	332	327	1.51
0,01	344	347	-0.872	340	340	0.000
0,02	354	361	-1.977	348	350	-0.58
0,03	362	374	-3.315	358	357	0.28
0,04	372	387	-4.032	366	364	0.547
0,05	382	399	-4.450	378	371	1.852
0,06	386	402	-4.145	388	379	2.32
0,07	392	417	-6.378	402	387	3.73
0,08	396	421	-6.313	406	396	2.463
0,09	396	421	-6.313	408	405	0.735
0,10	398	418	-5.025	406	409	-0.74
0,11	395	418	-5.823	406	402	0.985
0,12	394	398	-1.02	404	390	3.465

The results presented in Table 1 and the graphs of FIG. 8 show that the nature of the ongoing processes in the pattern and experimental research is the same. Average relative mistake between experimental data and data generated by the computer model is 3.319%.

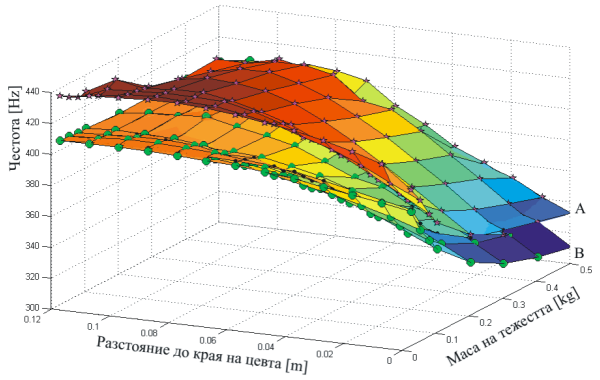

Fig. 9. Graphs of the value of the second frequency transverse vibrations resulting from the experimental shootings and computer models, depending on the distance of the mass to the muzzle cut.
A - schedule change frequency obtained from the computer model;
B - schedule change frequency derived from experimental firings.

III. STATISTICS HYPOTHESIS CHECKING

The statistics hypothesis can be checked by comparing of the dispersions of the experimental and analytical results [5] [6] [7]. The zero hypothesis is that the dispersion of data, received from the analytical model is commensurable with the dispersion of the experimental data [8].

Formula (1) can be used to check the statistics hypothesis [1]:

$$\chi_0^2 = \frac{SS}{\sigma_0^2} \qquad (1)$$

where:

$SS = \sum_{i=1}^{n}\left(y_{Ei} - \bar{y}_E\right)^2$ - corrected sum of the squares of the experimental investigation data;

$\sigma_0^2 = \frac{1}{n-1}.\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2$ - dispersion of the analytical model data;

$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$ - average analytical model data;

$\bar{y}_E = \frac{1}{n}\sum_{i=1}^{n} y_{Ei}$ - average experimental investigation data;

n - data number.

The zero hypothesis is rejected in cases, when $\chi_0^2 > \chi_{\alpha/2;n-1}^2$ or $\chi_0^2 < \chi_{1-\alpha/2;n-1}^2$ [1]. The values of $\chi_{\alpha/2;n-1}^2$ and $\chi_{1-\alpha/2;n-1}^2$ are tabu1lar [1].

The received results are presented in table 2.

TABLE 2 RESULTS OF ZERO HYPOTHESIS CHECKING

№	*Mass of weight [kg]*	α	χ_0^2	$\chi^2_{(0,025;9)}$	$\chi^2_{(0,975;9)}$
1	0,027	0,05	4,452111	23,3366	4,40778
2	0,057	0,05	5,892019	23,3366	4,40778
3	0,081	0,05	5,494996	23,3366	4,40778
4	0,105	0,05	4,674365	23,3366	4,40778
5	0,204	0,05	6,387244	23,3366	4,40778
6	0,303	0,05	7,087494	23,3366	4,40778
7	0,406	0,05	6,249967	23,3366	4,40778
8	0,506	0,05	13,92859	23,3366	4,40778

The results presented in Table 2 indicate that the null hypothesis can be considered a true computer model, and the same can be used for practical determination of the second frequency of own oscillations of the developed cross tubes for arms.

IV. CONCLUSIONS

1. The study of the possibility of determining their lateral oscillations of the barrel FEM shows the applicability of the method to determine the same, regardless of the complexity of the shape of the barrel and the presence of added mass at various points along its length.

2. The main advantages of creating a model of the barrel using the software are:

- it is possible to create a model that corresponds to the actual shape and dimensions of the barrel, regardless of its complexity;
- it is possible to design a model of the barrel with the added weight, taking into account the actual form and the actual place where the weight is placed;
- it is possible to adjust the accuracy of the resulting solution.

3. The main shortcoming of the computer model of the barrel is the need to purchase and study of relevant software, with which to carry out modeling, leading to a significant appreciation of the study and a large expenditure of time.

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Students' Financial Literacy Knowledge Research: The Case of Kauno Kolegija Higher Education Institution

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Abstract. **A person feels more confident and secure with good financial skills and knowledge in the face of increased inflation, energy crisis and geopolitical uncertainty. Therefore, financial literacy is one of the most important skills necessary for a modern person. The basics of financial literacy are included in the programs of primary and secondary schools in Lithuania. So, students of Higher Education Institutions should have basic financial literacy knowledge and skills. The purpose of this study is to assess student's level of financial literacy. For this reason, a survey of 1st year students of Kauno kolegija Higher Education Institution Technologies and Business Faculties was carried out in May – June of 2022. The survey consisted of questions and knowledge test tasks which were divided into four groups: budget, credits and debts, savings and investments, financial responsibility. The collected data were processed using the SPSS 29 software. It was assessed that the level of financial literacy of Kauno kolegija Higher Education Institution students is adequate. The quartile width of the financial literacy index of all respondents was about half of the total spread. That means that the spread of values between the quartiles is similar. It was observed that earning respondents are more tend to save than non-earning respondents when evaluating the differences in the context of saving habits. In addition, two-thirds of working students cut back on spending when money is tight. It was observed that the vast majority of working students do not tend to borrow from family or friends. A statistically reliable difference was obtained between the groups of working and non-working respondents when evaluating an investment, i.e. one third of working people tend to invest. Respondents named the main reasons for not investing: lack of knowledge and insufficient amount of money. Respondents who invest their savings usually choose to invest in cryptocurrencies, real estate, investment funds or their own business. Even four-fifths of unemployed students said that they wanted to learn more about money management when assessing their financial skills. The study found out that goal setting has a direct impact on reducing their expenses. In addition, a better financial situation makes it possible to regularly save and evaluate the financial situation before buying an expensive item. What is more, the ability to manage your finances directly depends on deepening your financial knowledge, encouraging you to compare prices when buying something, compare the conditions of different credit institutions. The received results show that the majority of Kauno kolegija Higher Education Institution students have a sufficient amount of general financial literacy knowledge, for example, they tend to plan their personal budget, borrow efficiently,**

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correctly assess investment risks, inflation and interest rates, and have long-term financial goals.

Keywords: budget, credits, investments, students' financial literacy.

I. INTRODUCTION

In everyday life people are constantly facing decisions about their personal finances: how to manage their household budget, for which purchases to borrow and for which to save, whether to invest, which investment instruments to choose, how to avoid falling into scams and how to choose a better way to save for the future.

A person with sufficient financial knowledge can better understand financial information and make decisions not only about everyday consumption but also about saving, investing, credit, pensions, life insurance, etc. This leads to better financial behavior. Financial knowledge can help them to assess their current financial situation more objectively and help them to avoid financial problems [1].

An analysis of financial literacy studies [2], [3], [4], [5], [6], [7], [8], [9] which were made around the world showed that people have a low level of financial literacy in most countries (except for countries such as Australia, Canada and Denmark where are considered to have higher financial literacy level).

Most financial literacy surveys conducted in Lithuania showed that Lithuanian residents are also characterized by low financial literacy [10], [11]. Residents are not tending to plan their personal budgets and save for the future. This can lead to over-indebtedness. And it can become a burden for households and threatens the stability of public finances [12]. Though the results of these studies have been disappointing it has been improving in recent years [13].

The low level of financial literacy has led to its inclusion in the list of key skills needed by modern people and has become a priority in EU education in the 21st century. This has created a need for additional financial education in schools. One of the reasons why financial literacy is so important for children is that financial attitudes, habits and norms start to form between the ages of 6 and 12. It can have a long-term effect to teach children about money and their spending habits at this age [14].

In Lithuania, financial literacy is included in primary and secondary school curricula. So young people (as well as higher education students) should have basics of financial literacy knowledge and skills.

The financial literacy skills which are acquired at school are also important for students. Because they must balance their expenses, rent a house, get an education and secure a good future income. Today, they are living in an incredibly challenging economic situation. What is more, they will ultimately be responsible for their own financial well-being in such an economic situation. So, students need to develop the skills which will help them make their own choices among the many career and learning options available to them. What is more, they need to be able to manage their own incomes whether it's pocket money from their parents or a part-time job.

Lithuania has only episodic financial literacy assessments of schoolchildren, young or elderly people. Therefore, it is difficult to know what the level of financial literacy is, what determines it and what is the most important factor influencing the achievement of higher or lower levels of financial literacy.

The object of the research is the financial literacy knowledge of students at Kauno kolegija Higher Education Institution.

The aim of this study is to assess the level of financial literacy of students in Kauno kolegija Higher Education Institution.

The research objectives:

- To provide a theoretical underpinning for the study, distinguishing dimensions of budget; credits and debts; savings and investments; financial responsibility.
- To provide an analysis of the results of the research, highlighting the level of financial literacy of students.

The method of questionnaire survey was chosen for the research, SPSS (Statistical Package for Social Science) version 29.0 software was used for data processing, the obtained results are presented in figures and described in the text.

II. MATERIAL AND METHODS

The knowledge and understanding of financial concepts and risks, as well as the skills and attitudes to apply this knowledge and understanding in order to make effective decisions in a variety of financial situations, to improve the financial well-being of individuals and society, and to enable them to participate in economic life is known as financial literacy [2], [4], [13]. In other words, financial literacy is the ability to understand and effectively use a range of financial skills including personal financial management, budgeting, investing and taking financial responsibility.

A lack of financial literacy knowledge can lead to a number of problems, such as accumulating debts due to poor spending decisions or decisions not to save. This can lead to poor credit conditions, bankruptcy, foreclosure or other negative consequences. The failure to adapt to today's changes leads to social exclusion and poverty [15], [16]. High-quality financial education can help overcome this.

One of the instruments that can measure and assess the level of financial literacy is the financial literacy index. The Lithuanian financial literacy index was calculated for the first time in 2019. The survey questionnaire and the methodology for calculating the index were developed by researchers from Vilnius Gediminas Technical University (Vilnius Tech) [10]. The biennial survey asked people to answer questions related to saving, investing, personal

finance management, retirement and financial and economic phenomena. The financial literacy index stood at 43 out of a possible 100 points in 2019 and it was 45 out of a possible 100 points in 2021 [11].

In order to assess the knowledge of financial literacy of Kauno kolegija Higher Education Institution 1st year students, a questionnaire was designed. A questionnaire covered four dimensions: budget; credits and debts; savings and investments; financial responsibility.

It analyzed the questionnaires used by other Lithuanian [17], [18] and foreign [2], [19], [20], [21], [22] authors or organizations such as the Free Market Institute of Lithuania, Swedbank, the OECD and the World and the Americas region's platforms for assessing and learning about financial knowledge before developing the questionnaire. Then the selected questions were adapted (considering the economic situation in Lithuania) to test the financial literacy knowledge of Kauno kolegija Higher Education Institution students.

The following principles were followed in the selection of questions [16]:

- Simplicity: questions are assessing knowledge of the essential elements of decision-making in the current era;
- Relevance: the questions are related to the concepts linked to people's everyday financial decisions throughout their life cycle;
- Brevity: the number of questions should be limited;
- Differentiation: questions are grouped by area.

The questionnaire consists of 57 questions: 12 general questions and 45 financial literacy questions divided into four groups:

- Budget (9 questions);
- Credits and Debts (6 questions);
- Savings and Investments (14 questions),
- Financial responsibility (16 questions).

The questions are grouped according to the financial literacy groups (Fig. 1).

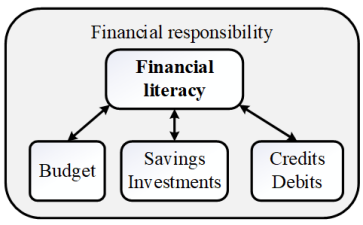

Fig. 1. Financial literacy model.

A targeted anonymous survey was carried out between May and June of 2022. 219 respondents of 1st year students of Kauno kolegija Higher Education Institution Faculty of Technology and Faculty of Business were interviewed. There are 54.3 % of men and 45.7 % of women of these respondents. Respondents' distribution across study programs and faculties is shown in Fig. 2.

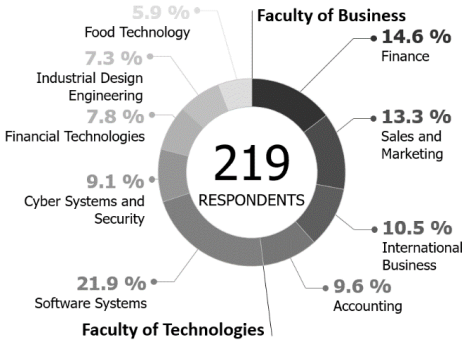

Fig. 2. Respondents distribution across study programs.

Respondents were briefly informed about the objectives of the research before they take the survey and completed the paper or electronic survey.

SPSS 29 and MS Excel were used for the statistical analysis of the survey data.

Each correct answer in the questionnaire (designed to test knowledge) was given a score of 2 and an incorrect answer was given a score of 0 to calculate the financial literacy index. Accordingly, a partially correct answer was scored from 0.5 to 1.5 points depending on the number of partially correct answers in the question. The maximum score that could be obtained by answering all the questions correctly was 83 points: budget – 13, credits and debts – 12, savings and investments – 26, financial responsibility – 32.

Numerical characteristics (mean, median and quartiles) were used to measure the financial literacy index. Numerical characteristics showed how the values of the financial literacy index are distributed across all survey participants.

III. Results and Discussion

The results of the anonymous surveys were analyzed from different perspectives in order to identify the assessments and interrelationships between the different groups of financial literacy.

When it was assessed respondents' financial situation 64.4 % of respondents answered that their expenses do not exceed their income and 59.4 % of them plan their income (from which even 27.4 % have a 6-month plan for their income and expenses). 74.4 % of respondents reduce expenditure when they run out of money. Respondents try not to borrow (78.8 %) but if they do borrow, they do it responsibly (98.2 % of respondents are assessing the terms of the loan). 62.1 % of respondents have emergency savings. 65.8 % of respondents are planning to invest in the future in cryptocurrencies, real estate, their own business, investment funds, precious metals and currencies. While those respondents who do not invest refer to a lack of financial knowledge as one of the reasons (Fig. 3).

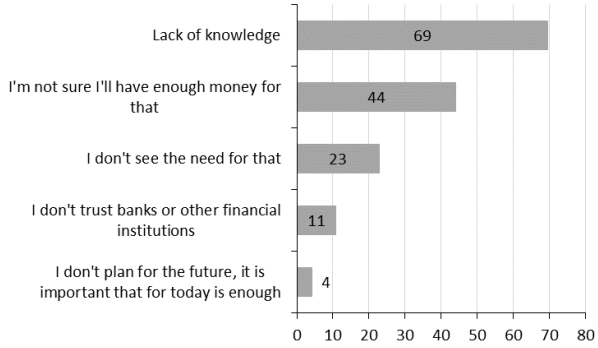

Fig. 3. Reasons for respondents' non-investment.

69.9 % of respondents set long-term goals responsibly, follow a budget plan, save regularly, compare prices when buying something, work extra hours to cover expenses, pay their taxes on time and improve their financial knowledge.

Thus, it can be stated that the vast majority of Kauno kolegija Higher Education Institution respondents have the right habits of personal finance management, tend to know how to plan a personal budget, borrow responsibly and correctly assess investment risks.

Financial responsibility. When it was assessed respondents' financial responsibility, it was observed that the most common ways to get money were borrowing from parents or friends ($r = 0.351, p < 0.01$) and taking money from savings ($r = 0.189,\ p < 0.01$). The better financial situation makes it easier to save regularly ($r = 0.207, p < 0.01$) and to take a look at one's financial situation before buying an expensive item ($r = 0.189,\ p < 0.01$).

Savings and investments. When it examed respondents' savings and investment behavior, 23.3 % of those who believe that they need to have 4-6 months of income in reserve would sell an item if they ran out of money (versus 9.8 % of those who believe they need to have 3 months in reserve, $p = 0.027$). 26.3 % of respondents who has 4-6 months' income for a "rainy day" think that they will have too little money to invest (versus 65 % with 3 months' income in reserve, $p = 0.015$). 91.7 % of respondents (with 4-6 months of income in reserve) believe that if they could invest, they would invest in different financial products which would guarantee their financial security (versus 76.8 % of respondents whose financial situation is uncertain, $p = 0.02$) (Fig. 4.).

Credits and debts. The most common ways of borrowing money are to borrow from family or friends ($r = 0.304, p < 0.01$), take from savings ($r = 0.205, p < 0.01$), take credit or consumer loan ($r = 0.153, p < 0.05$) or use an existing credit card ($r = 0.209, p < 0.01$).

Budget. If women have remaining money, 44 % of them sometimes plan their budget and future expenses (versus 24.4 % of men, $p = 0.005$). When respondents run out of money: even 63 % of women take it from savings (versus 39.5 % of men, $p = 0.001$); 83 % of women reduce spending money (versus 67.2 % of men, $p = 0.008$), sell an item (24 % of women, versus 9.2 % of men) and 32 % of women borrow money from family or friends (versus 19.3 % of men, $p = 0.031$). Also, women are more likely than men to feel responsible for repaying the loan if the person they have guaranteed, fail to meet commitments (77 % of women agree versus 61.3 of men, $p = 0.013$). 84 % of women are more likely to tend not to invest (versus 62.2 % of men, $p < 0.001$). And even 95 % of women prefer to keep their savings in an account or at home in cash (versus 84.9 % of men, $p = 0.0015$).

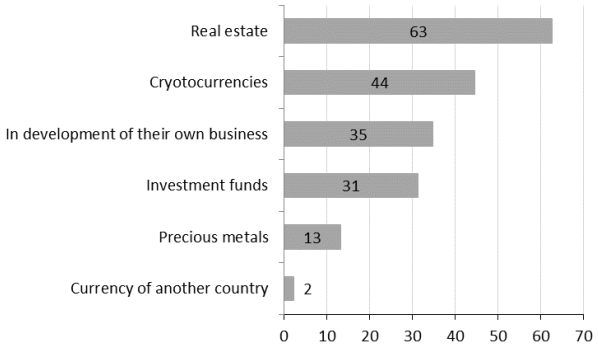

Fig. 4. Financial investment instruments.

The financial literacy index of Kauno kolegija Higher Education Institution students shows that the level of financial literacy of Kaunas kolegija Higher Education Institution students is average.

It can be seen that 50 % of respondents had a knowledge score above 8 (out of a possible 13), 25 % of respondents had a knowledge score below 7 (out of a possible 13) and the remaining 25 % had a knowledge score above 9 (out of a possible 13) for the budget group of questions. The lowest and highest scores accordingly were 4 and 11.5 (Fig. 5).

Half of the respondents' knowledge exceeded 10 points (out of a possible 12), while a quarter of the respondents' knowledge was below 9 points (out of a possible 12) or above 11.5 points (out of a possible 12) for the credits and debts group of questions The lowest and highest scores accordingly were 4 and 12 (Fig. 5).

50 % of respondents scored above 18.9 (out of a possible 26) and 25 % scored above 21.6 (out of a possible 26) in the savings and investments group. However, there were also some respondents whose score did not exceed 14.9 points (out of 26 possible), the lowest and the highest scores accordingly were 5.4 and 25.4 (Fig. 5).

The group of financial responsibility questions had 32 points. It can be noted that half of the respondents' knowledge of financial responsibility exceeded 22 points (out of a possible 32), a quarter of the respondents' knowledge did not exceed 20 points (out of a possible 32), and the remaining 25% scored above 25 points (out of a possible 32) in this group of questions. The lowest score was 11 and the highest was 30 (Fig. 5).

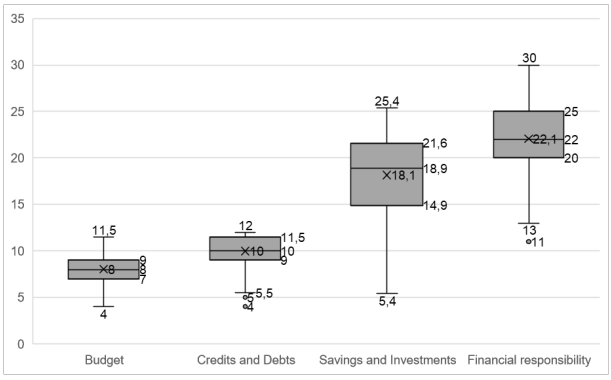

Fig. 5. Visualisation of financial literacy index quartiles (by questions groups) of respondents' answers.

The overall score of the financial literacy index (quartile width 2÷6.7) suggests that respondents' knowledge of savings and investings is more uncertain than their knowledge of budgeting, credits and debts, and financial responsibility. Respondents' general knowledge is adequate, but it is at different levels. There were respondents with a very low level of knowledge and those with a sufficiently high level of knowledge (Fig. 6).

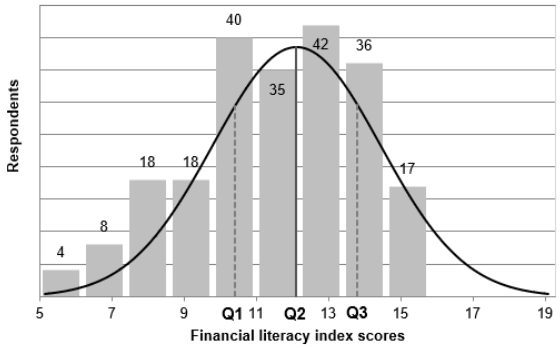

Fig. 6. Distribution of financial literacy index scores.

A non-parametric Chi Square test and correlation analysis were used to determine whether differences exist between demographic groups and what determines financial literacy level. When statistically significant differences ($p < 0.05$) are examined it can be noted that:

- 77.1 % of Faculty of Business respondents would like to know more about money management (versus 63.2 % of Faculty of Technology, $p = 0.045$); 64.8 % of Faculty of Business respondents don't spend more money than they receive (versus 50.9 % of Faculty of Technology, $p = 0.08$). 81.9 % of Faculty of Business respondents are likely to first compare the terms of different credit institutions before buying things on credit (versus 64.9 % of Faculty of Technology, $p = 0.14$). When respondents think of buying an expensive item, 53.3 % of Faculty of Business respondents would tend to save (versus 30.7 % of Faculty of Technology, $p < 0.001$).

- 61.4 % of Faculty of Technology respondents improve their financial knowledge independently (versus 41.9 % of Faculty of Business, $p = 0.004$). Even 89.5 % of Faculty of Technology respondents say they acquire financial knowledge outside Kauno kolegija Higher Education Institution (versus 67.7 % of Faculty of Business, $p < 0.001$).

When it looked for differences between the groups of respondents who earn or who "live out of parents' pockets", we can see that:

- 53.7 % of working respondents tend to agree with the statement that their current expenses are lower than their income (versus 34.7 % unemployed respondents, $p = 0.037$); 67.8 % of working respondents reduce their expenses when they run out of money (versus 17.3 % unemployed respondents, $p = 0.012$); 77.5 % of working respondents do not like to take money from relatives (versus 60.3 % unemployed respondents, $p = 0\,009$). Similarly, 80.2 % of working respondents are not willing to borrow (versus 68.4 % of unemployed respondents, $p = 0.045$).

- Working respondents are more likely to save than unemployed respondents. 52.9 % of the working respondents save regularly, putting aside a certain amount each month (versus 38.8 % of unemployed respondents, $p = 0.089$, this is not statistically significant). 16.5 % of the working respondents are involved in saving in pension funds (versus 4.1 % of unemployed respondents, $p = 0.003$). 55.3 % of working respondents do not plan to invest due to a lack of knowledge (versus 83.8 % of unemployed respondents, $p = 0.007$) (Fig. 7).

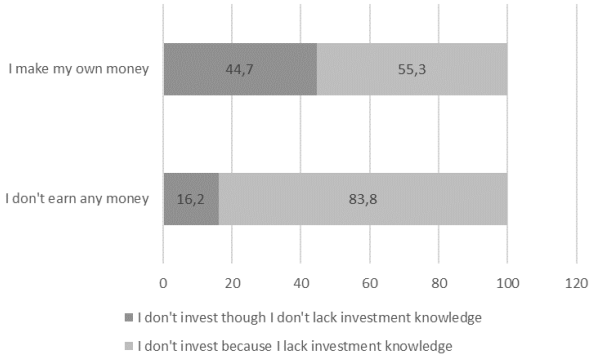

Fig. 7. Correlation of working and non-working respondents with reasons for non-investment/

When it was looked for a correlation between savings and investments and budgeting, it can be seen that planning future income and expenditure is directly related to saving habits ($r = 0.213, p < 0.01$). When respondents run out of money then spending is reduced but the investment is not planned because there is not enough money ($r = 0.265, p < 0.05$) and they usually have a lack of knowledge ($r = 0.289, p < 0.05$). When there is an opportunity to earn extra money, investing is more acceptable and possible ($r = 0.137, p < 0.05$). Respondents who rate their ability to manage their finances are good enough are more likely to invest ($r = 0.42, p < 0.01$) and not keep their money in a bank account or at home ($r = 0.209, p < 0.01$).

When it was looked at the financial responsibility and budget link it can be seen that setting long-term goals has a direct impact on cost reduction ($r = 0.251, p < 0.01$).

Respondents report that when they run out of money they are able to save money because they are able to earn extra money ($r = 0.146,\ p < 0.05$). And the extra work allows them to pay bills and cover expenses ($r = 0.290, p < 0.01$). The ability to manage one's finances is directly related to financial knowledge ($r = 0.222$, $p < 0.01$) and it is encouraging to compare prices when buying something ($r = 0.139,\ p < 0.05$) or to compare the terms of different credit institutions ($r = 0.205, p < 0.01$).

In summary, almost a third (33.1 %) of respondents are aware of the timeframe needed to access finance for a "rainy day". Almost a third (31.7 %) of respondents sometimes spend more than they receive. It can be assumed that the smaller the amount of money they have in reserve, the more they are willing to buy things on credit. Respondents named the main reasons for not investing: lack of knowledge, insufficient amount of money (91,3 % of respondents think that they will not have enough money for investing in the future) and do not see the need for investment ($r = 0.238, p < 0.05$). Although most of them (over 75 %) understand about diversification of investment.

Working respondents spend more than their income. When they run out of money then they cut back money unless they receive money from relatives but are not willing to borrow from them. It was observed a statistically significant difference that working respondents are more tend to save than unemployed respondents; 34.7 % of working respondents are likely to invest (versus 19.4 % of unemployed respondents $p = 0.012$) when evaluating the differences in the context of saving habits. Also, working respondents tend to save and save a regular amount each month. What is more, they tend to save in pension funds.

Both men and women tend to say that they did not learn the basics of financial management at Higher Education Institutions. It can be noted that even 87.4 % of men agree (versus 69 % of women, $p = 0.001$) with that. More of Faculty of Business respondents are deepening their financial knowledge outside Kauno kolegija Higher Education Institution. In terms of their financial management skills, 81 % of women would like to learn more about money management (versus 60.5 % of men, $p = 0.004$). 71 % of women would like to improve their financial literacy in the area of savings (versus 54.6 % of men, $p = 0.013$). When unemployed respondents are assessing their financial skills, even four-fifths of them said that they want to learn more about money management (versus 61.2 % working respondents, $p = 0.003$) in Kauno kolegija Higher Education Institution.

IV. Conclusions

A questionnaire has been developed after the theoretical justification of the study and after the analysis of the instruments used by Lithuanian and foreign authors and organizations which measure financial creditworthiness. The questionnaire distinguished between the groups of budget, credits and debts, savings and investments and financial responsibility.

The analysis of the results of the study suggests that:

- The study found that goal setting has a direct impact on reducing students' expenses. Students who are able to manage their finances have more financial knowledge because they are improving their financial knowledge and are more likely to compare the prices of things or the terms of different credit institutions.

- In addition, two-thirds of working students cut back spending when money is tight. It was observed that the vast majority of working students do not tend to borrow from family or friends.

- The ability to manage your finances directly depends on deepening your financial knowledge, encouraging you to compare prices when buying something, compare the conditions of different credit institutions.

- In addition, a better financial situation makes it possible to regularly save and evaluate the financial situation before buying an expensive item. Students' saving habits depend on budget planning. Students are more likely to put money aside for a "rainy day" than to invest it. Students who invest their savings usually choose to invest in cryptocurrencies, real estate, investment funds or their own business.

- In terms of gender differences, women are: much more likely to receive scholarships; learned "to do charity" in the family; when they run out of money they sell an item or borrow from family and / or friends; interested in and deepen knowledge about money management; feeling responsible for repaying their loans if the person they have guaranteed for fail to meet commitments; not willing to invest their savings. On the other hand, men are much more likely to invest and they are willing to take risks when investing (for example, investing in cryptocurrencies) even though they know that an investment with a high return is very risky; they look into and learn about the conditions of loans and credits; they put aside money when they have money left over and plan where to spend it later on; if they run out of money, they take their savings or cut down on spending money. When it comes to financial management and financial literacy, women still stick to stereotypical activity.

Highlighting the students' level of financial literacy and the financial literacy index, it can be observed that the student's general knowledge is adequate, but it is at different levels. Among the students who participated in the study dominated the average level of financial literacy.

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Need and Expectations for Learning in a Stem Environment

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***Abstract*. In the last decade, the need for specialists in the field of engineering and exact sciences emerged in Bulgaria and around the world. This led to the launch of a National Program for the construction of stem centers in schools. From the Veliko Tarnovo region, 16 schools joined the program at different stages, where STEM centers are being built or are already functioning in various subjects, which significantly support the preparation of quality personnel for the Bulgarian economy. A review and analysis of the expectations of teachers and students from work in centers with an engineering focus and training in natural sciences was made. At the next stage, an analysis and evaluation of the effect of the implementation of these innovative centers will be done.**

Keywords: effect; engineering sciences; experiments; natural sciences; STEM center; students.

I. Introduction

With Decision No. 285 of April 30, 2020 of the Council of Ministers, amended by Decision No. 937 of December 17, 2020, twenty-one national programs (NP) for the development of secondary education were approved. One of them is the NP "Building a school STEM environment". It is aimed at schools with innovative practices and those with the potential to develop innovations in the field of natural sciences, digital technologies, engineering thinking and mathematics (STEM) [1], [2], [3]. The program was born from the need to create, furnish and equip dedicated spaces for applying the competence approach in the field of natural-mathematical sciences and technologies. This space should have an unexpected and attractive design that will attract children and keep them in school even after their classes are over. They should always feel welcome in the STEM center, which, with its welcoming and modern atmosphere, invites them to create, communicate and use it in unexpected ways [4], [5].

By building a school STEM environment, it is aimed to achieve not only a change in the physical environment - improvement of the internal architecture and the furnishing of existing spaces, but also the use of new technologies in the educational process, integrated educational content, innovative methods of teaching and management of the educational process. The set goals are related to increasing students' motivation for learning science and mathematics, increasing their commitment, skills and achievements and creating conditions for project-based learning. Schools with a built-in STEM environment must become a model for implementing a new educational process that goes beyond the classroom-lesson system, according to which disciplines are taught separately, without a clear connection to each other [6], [7], [8].

II. Materials and Methods

The change is connected on the one hand with the physical environment - areas for STEM activities, furniture and interior design supporting learning and creativity, and on the other hand with the skills and preparedness of teachers to implement integrated lessons, apply modular learning, introduce integrative or new subjects, extracurricular activities with a focus on science, mathematics, engineering and technology. The change should affect the preliminary planning of the lessons, their conduct, the assessment in the lessons and the methods and tools used to achieve a project-based or problem-based educational process [2], [9].

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The physical environment and the activities in it should be accessible to a significant number of students in the school, including those with special educational needs, should not tolerate discrimination based on gender, economic situation, culture, racial or ethnic affiliation, mother tongue, etc [10], [11], [12].

The program of the Ministry of Education and Science lists in detail the types of projects by Activities (Activity I: Large projects - up to BGN 300,000 and Activity II: Small projects - up to BGN 50,000) and by stages of education (for primary, for junior high school and high school stage) [1], [13], [14].

In the country, program activities started in the summer of 2020 with an application and selection procedure. Out of a total of 81 schools in Veliko Tarnovo district, 25 schools submitted project proposals and 14 were approved. External experts appointed by order of the Minister of Education and Science carried out the organization, selection and ranking of the projects. The following schools have been approved by the Veliko Tarnovo region [2], [15]:

TABLE 1. SCHOOLS FROM THE VELIKO TARNOVO REGION, APPROVED UNDER THE NP "BUILDING A SCHOOL STEM ENVIRONMENT"

№	Populated place	Name of the school	Type and name of the constructed STEM environment
Schools under Activity I under NP "Building a school STEM environment", Veliko Tarnovo district			
1	Veliko Tarnovo	PMG "Vasil Drumev"	Center for Natural Sciences, Research and Innovation
2	Veliko Tarnovo	"Bacho Kiro" Elementary School	Center for Natural Sciences, Research and Innovation
3	Veliko Tarnovo	PGSAG "Angel Popov"	Center for Technologies in the Creative Industries - BIM Center
4	Veliko Tarnovo	PGT "Dr. Vasil Beron"	Center for Natural Sciences, Research and Innovation
5	Gorna Oryahovitsa	SU "Vicho Grncharov"	Center for Natural Sciences, Research and Innovation "STEM researchers - we have the future"
6	Svishtov	LNG "Aleko Konstantinov"	Center for Technology in the Creative Industries STEM Center for Careers of the Future
7	Svishtov	SU "Dimitar Blagoev"	Center for Natural Sciences, Research and Innovation "STEM Center Pitko"
Schools under Activity II under the NP "Building a school STEM environment", Veliko Tarnovo district			
1	Veliko Tarnovo	PGE "Alexander Stepanovich Popov"	A classroom for creative digital makers
2	Veliko Tarnovo	SU "Vladimir Komarov"	Classrooms for creative digital makers
3	Veliko Tarnovo	"Petko Rachev Slaveikov" Elementary School	School Center for Energy Efficiency and Innovation - "STEM Learning in the Natural Sciences"
4	Gorna Oryahovitsa	PGLPI "Atanas Burov"	A school STEM center for creative digital makers
5	Polikraishte village	OU "St. St. Cyril and Methodius"	"Classroom for Creative Digital Makers" / physics and robotics /
6	Parvomaitsi village	"Elin Pelin" Elementary School	A classroom converted into a workshop area
7	Svishtov	PDTG "Dimitar Hadjivasilev"	Center for Creative Digital Creators "STEMB - STEM + Business"

The study was done by filling out a survey using Google forms with teachers and students from the approved 14 schools in the Veliko Tarnovo district. The survey was conducted in the months of May-June 2022 at the start of the projects. In April-May 2023, a new survey will be conducted in order to reflect the dynamics of the use of the STEM centers and the results obtained. At the end of the next school year, a new survey will be conducted and the extent of the expected and obtained results will be reflected.

109 teachers and 358 students participated in the survey in 2022. The survey was divided into 5 sections and had 50 questions, and they were different for the categories of teachers and students, due to the specifics of their activity.

The approved schools are from the three largest municipalities of the region - Veliko Tarnovo, Gorna Oryahovitsa and Svishtov (table 1).

III. RESULTS AND DISCUSSION

Results of the monitoring of the educational process of schools from the Veliko Tarnovo region with a built STEM environment: Of the total of 14 built STEM environments in 8 schools, they functioned more than three months ago during the monitoring period 05/05-24/06/2022. In the remaining 6 schools, the training in them it started later due to objective reasons, e.g. renovation at the school (PGSAG "Angel Popov", PGT "Dr. Vasil Beron", PGE "Al. St. Popov"), absentee training due to the Covid-19 pandemic, delayed delivery of equipment [1], [3], [13], [16].

The subject of the performed monitoring is the organization and activities during the educational process in the constructed STEM environment in the school.

Objectives of monitoring:

- to follow the organization of the educational process by using the opportunities and resources in the dedicated STEM environment;
- to track the implemented activities during training in the STEM environment;
- to track the satisfaction and learning outcomes of the students in the subjects when using the constructed STEM environment [13], [17].

The center is not just a renewed learning space with new technologies, but a model for an open, inspiring and creative learning environment. The successfully built school STEM center unites:

- a space adapted for learning through experience, creation and experimentation;
- learning content supporting the development of STEM competencies (e.g. integrated learning content modules, integrated lessons, new subjects, extracurricular activities, etc.);
- innovative teaching methods, encouraging creativity and critical thinking among students;
- organization of the learning process, allowing full and in-depth learning;
- technologies tailored to the goals of the curriculum and creating conditions for practical work with modern tools and programs;
- effective leadership and management of the STEM center;
- active cooperation with business and the community [3], [14], [18].

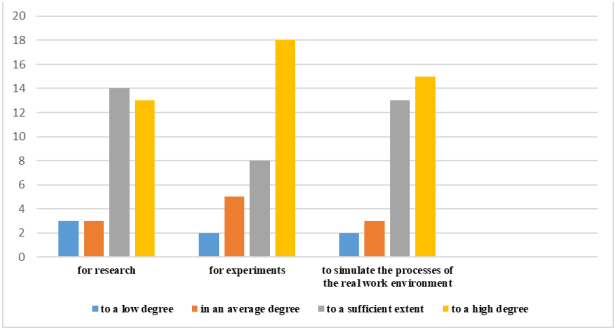

Fig. 1. To what extent does the STEM center facilitate learning

The dedicated STEM environment in the schools of the Veliko Tarnovo region represents a transformation of school classrooms, corridors and other spaces by creating conditions for teamwork, encouraging practical experiments and interactive learning, and developing students' social contacts. The environment may focus on the study of natural sciences, engineering sciences, mathematics, technology, or a combination thereof (fig. 1).

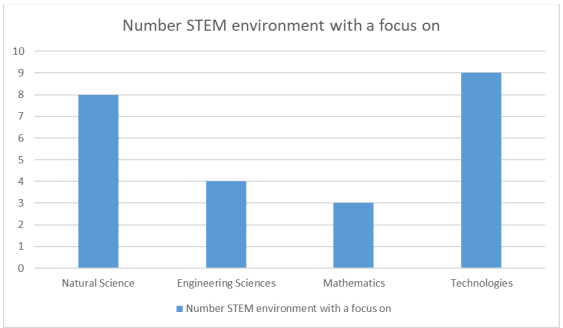

Fig. 2. Number of STEM environments with a focus on the four strands

The STEM environment has a focus on one or more of the four areas, with four schools focusing only on science (fig, 2). These are "Bacho Kiro" Elementary School - Veliko Tarnovo, "P. R. Slaveykov" - Veliko Tarnovo, SU "Vicho Grncharov" - Gorna Oryahovitsa and SU "Dimitar Blagoev" - Svishtov. In these schools, there is an opportunity for the integration of natural science knowledge. The teams for organization, management and implementation of school processes claim that through the integration of the learning content of man and nature, biology and health education, physics and astronomy and chemistry and environmental protection, students have the opportunity to understand the connections between the disciplines and get answers to questions such as: "Why do I need to know this?", "Where will I use what I am currently learning?" and others. In "Vicho Grncharov" SU, the integration is between the curriculum of biology and health education and information technologies. Key competences in natural sciences and IT are developed through transdisciplinary project-based learning based on hands-on work in groups with virtual reality software and laboratory research. The Center for Natural Sciences, Research and Innovation is also used for teaching the newly introduced subject "Virtual Biology" in section A of the curriculum in grade XII for the academic year 2021-2022.

In two high schools, the focus of the environment is only on technologies - PDTG "D. Hadjivasilev", Svishtov and PGLPI "Atanas Burov", Gorna Oryahovitsa. In them, digital competences are integrated with mathematics in programming classes and general-purpose application programs, as well as with the educational content of vocational training subjects.

An innovative learning environment with a focus on STEM involves a change in one or more elements of the educational process: educational environment, learning content, and organization and management of school processes (fig. 3).

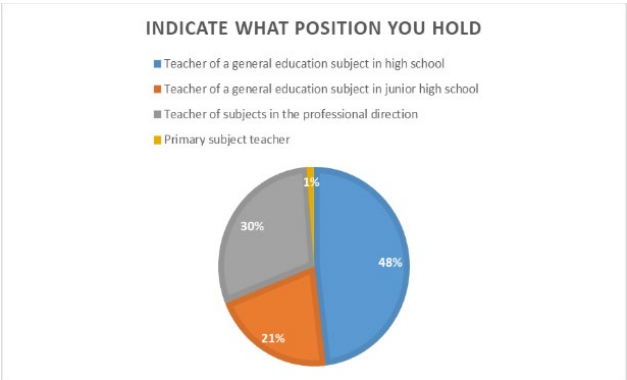

Fig. 3. Duties of subject teachers

All schools indicated that the change covered more than two elements. There is definitely a change in the educational environment, which is most often associated with a change in the teaching methodology. The change in the educational content is interpreted as the study of subjects in the school curricula of the innovative schools

and with the order of the subjects studied in the curricula. According to the Preschool and School Education Act, Innovative schools are schools that achieve improvement in the quality of education, such as:

1. develop and introduce innovative elements regarding the organization and/or content of training;
2. organize in a new or improved way the management, training and learning environment;
3. use new teaching methods;
4. develop educational content, curricula and study plans in a new way [2].

It can be seen that the inclusion of the school in the List of Innovative Schools provides ample opportunities to achieve very good results from the educational process. Very similar and complementary activities are implemented in the innovative and in the schools with an established STEM environment. Of the fourteen schools from the Veliko Tarnovo region under Activity I and Activity II of the NP "Building a school STEM environment", a total of 10 are included in the List of Innovative Schools for the academic year 2021-2022, adopted by Decision No. 523 of the Council of Ministers of 22.07. 2021

In order for the built STEM environment to function effectively, the need for a change in the organization and management of school processes has been realized. In schools, a team has been formed for organization, management and implementation of school processes. Team members are the principal and/or deputy principal and teachers, with the total number varying from 2 to 5. Each member of the team has clearly defined tasks at the various stages of building and functioning of the environment.

There is an effort to use the built STEM environment by more students in the school. In a conversation with the directors, the idea arose of preparing time schedules (for a month) for its use, which will ensure optimal access to the equipment of the largest number of classes.

Most often, the furnished STEM environment is used in the compulsory study hours of general education/professional/profiled training. In vocational high schools, the centers are also used for educational practice. Two schools ("Elin Pelin" Elementary School - Parvomaitsi village and "Vasil Drumev" Primary School - Veliko Tarnovo) indicate that interest-based activities are also held in the middle.

About 45% of primary school students in Activity I and Activity II of the NP "Building a school STEM environment" also conduct lessons in these centers/classrooms. Over 120 teachers teach in the built STEM environment of these 14 schools from the Veliko Tarnovo region.

As used methods and tools for teaching and learning in the STEM environment, the "Flipped Classroom", project-based learning, "learning by doing" model, innovative methods and tools for planning and teaching lessons are indicated. This also necessitates the application of different types of assessment.

Using the resources of the STEM environment enables the acquisition and application of 21st century skills (communication, collaboration, critical thinking, creativity, information and media literacy, technological literacy, initiative, flexibility, productivity, social and leadership skills). The time of their operation and use for the academic year 2021-2022 is relatively short, but it is planned to conduct classes and projects with practical experience and create

of "physical products" to encourage interest in STEM disciplines. Students will be engaged in solving real life problems and the world around them.

All schools have built effective cooperation with business representatives, with external organizations or individuals. The cooperation is expressed in the development of the project proposal, the delivery of the equipment, the holding of classes and consultations, the provision of monetary scholarships for the outstanding students. In one school, a local business representative was brought in as a speaker and held classes in the STEM center.

During the visits, the following findings were made:

1. PMG "Vasil Drumev", Veliko Tarnovo - built and functioning Center for Natural Sciences, Research and Innovation from the academic year 2019-2020. In the STEM center, classes are held in biology and health education, chemistry and environmental protection, computer mathematics, fundamentals of robotics with microcontrollers, programming for embedded systems. Employment is planned when preparing the weekly schedule. Part of the practical lessons of the professional education classes are also held there. In this environment, activities are also held according to the interests of the "Energy and Environment" club. Attended classes on "Fundamentals of Microcontroller Robotics" and "Introduction to Programming". The resources of the built STEM environment are fully utilized. A "learning by doing" model is observed in the classes. Students and teachers express satisfaction with learning in this environment and are willing to spend hours there;

2. LNG "Aleko Konstantinov", Svishtov - built and functioning during the II term of the academic year 2021-2022. It is a series of separate spaces with equipment and furniture for vocational training classes. In the STEM center, the practical lessons of the various specialties are held. Theory classes can be held at the center after prior request from the teacher, if availability allows. Practice lessons were observed in XIc (I group) - internal combustion engines, XIc (II group) - computer networks; educational practice in HB class; Mechatronic systems in motor vehicle technology in the 11th century. The technique used enables students to experience different situations representing real problems, solve case studies or develop project tasks. Students with interest work in class and demonstrate what skills they are acquiring;

3. "Bacho Kiro" Elementary School, Veliko Tarnovo - Center for natural sciences, research and innovation with

an emphasis on natural sciences. Attended classes in physics and astronomy in class VII. Full use is made of the equipment and furnishings - multi-touch display for monitoring objects in real time, portable computers for working in groups with a sky map in real time. For several hours, students work in small groups on an assigned task. Objects on the star map are tracked in real time, students' knowledge of the macro and micro world is integrated from a physical and chemical point of view. Views on the construction of building blocks, stars, and galaxies are examined. The built STEM center provides real opportunities to implement an integrated approach in science education. There is an opportunity to conduct laboratory exercises, as well as to work on research projects. Teachers and students express satisfaction and feel very good in this environment. The management of the school sets itself the task in the coming months to develop a concept for the work in the STEM center - organization, methodology, used resources. There is also a software product to be purchased to be used in science classes.

4. SU "Dimitar Blagoev", Svishtov - constructed and functioning Center for Natural Sciences, Research and Innovation "STEM Center Pitko". It is possible to conduct laboratory exercises on man and nature, chemistry and environmental protection, physics and astronomy and biology and health education. Demonstrations and simulations of real processes are used for visualization, discussions and debates can be held to solve case studies. Classes were attended in physics and astronomy in class X and in chemistry and environmental protection in class VII. On the day of the monitoring, 3 teachers work in the center. They are satisfied with the created working conditions. They say that they have everything necessary for a full-fledged educational process in natural sciences - tools, materials, electronic resources. The STEM center is put to full use in science classes. Provides excellent opportunities to achieve the expected outcomes of the study programs. Teachers and students share that the environment has a positive impact on their work. They want all classes in Man and Nature, Physics and Astronomy, Chemistry and Environmental Protection, and Biology and Health Education to be held there "...because they feel like explorers."

IV. CONCLUSIONS

I believe that the results achieved so far are related to both the renewal of the material base and the motivation of the students. By studying in a STEM center, they get a new experience and an opportunity to gain experience that takes them from accepting the new content and information, through its analysis and in-depth research, to its practical application and testing. It is through this process that the interest in the given knowledge increases, and once ignited, it can be easily channeled into the development of specific skills that will help the realization in a number of technological and other spheres.

The easiest integration of educational content is achieved in man and nature and in the subjects of the professional training of students in high school.

In the next academic year, a change in teaching methods in the STEM environment is to be sought. To apply more broadly the project-based learning principle, learning by doing, inquiry method and other interactive methods.

V. ACKNOWLEDGMENTS

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Video Projects as a Component of Inclusive Competence of Future Teachers

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Abstract. **In our paper, we propose to focus on the use of video products in the educational process of teacher education in Ukraine.**
First of all, it is important for us to present a justification of the features and importance of using video projects as part of theoretical material / educational content / online and offline courses. After all, the use of video projects allows to deepen the knowledge of future teachers, including audiovisual involvement in the perception of terminology, complex elements of teacher organization, legislation or other theoretical aspects.
Secondly, we believe that it is worth noting and presenting the experience of Ukrainian students of pedagogical specialties' involvement in video projects (in particular, the creation of a social video, etc.). After all, such work allows you to reassess your own skills in using technology, acquire new knowledge, formulate a strategy for implementing project-based learning in secondary school practice, and build strong cause-and-effect relationships between the knowledge and experience of using it through technology and social media.
All of this together allows us to observe the formation of a future teacher who is not separated from the challenges of the technology world, but who uses the opportunities of our time in a harmonious and high-quality way.

Keywords: inclusive competence, teachers' trainings, video projects.

I. INTRODUCTION

The realities of the Ukrainian educational system allow us to talk about changes, and these are caused not only by reforms and innovations, but also by events and their development, which «dictates life itself». After all, today's students, who will soon become specialists who will work directly with children in our country, are experiencing innovations and the need to adapt to a new format of education from year to year, which were first caused by the 2019-2021 pandemic and then continued with the full-scale invasion of our country in 2022. Although 2022 is only a continuation of what began in 2014. But this is not the issue of our work.

Despite the limitations in communication, communication, technical equipment, and in the face of a direct threat to the health and lives of all participants in the process, we had to not only study, but also teach how to adapt and, in some cases, modify educational content in accordance with students' capabilities and knowledge needs that would allow future teachers to be prepared to work with children with special educational needs in special rapidly changing conditions.

That is why the purpose of our study was to investigate the peculiarities of using and creating video projects by students of pedagogical specialities to develop inclusive competence.

In this aspect, we believe that the use of various forms of video for educational purposes (video clips, documentaries, animated films, video projects and online courses, lectures) has been helpful, as it «helps bring new and imaginative perspectives to almost any subject matter, as it encompasses the systematic and creative blending of product and idea technologies and engenders teaching and learning processes within and across disciplines» [1].

Among the main purposes that we pursue in this scientific review is the identification and study of video projects as a component of the educational process in preparing students for pedagogical activities that require inclusive skills of adaptation and modification of educational content, building an effective strategy for interaction with a child with special educational needs in real life.

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II. Materials and methods

In order to organise the activities of students within the framework of video projects, we needed to analyse the existing «balance» of information on this topic, as the questions we raised in our online audience concerned inclusion and work with children with special educational needs. Therefore, first of all, we turned to the scientific justification of how video projects can and should be used in the educational process.

In addition, all this was complicated not only by technical and interaction issues, but we had to objectively incorporate into our practice the asynchronous learning method, which «combines self-learning with asynchronous interactions that facilitate learning, and this can be used to facilitate the learning process in traditional education, distance learning and professional development» [2]. After all, being in the classroom during the pandemic and in moments of direct threat to the life and health of individuals required teachers to modify learning tasks in accordance with «unpredictable» changes without losing the quality and effectiveness of educational content.

Therefore, all video-based tasks should be selected «taking into account life experience, since they usually model life situations» [3], and also allow you to determine the target audience; justify the practical significance of the project; formulate the topic and purpose of the project; organise participants into microgroups, etc. In this regard, we should remember one of the fundamental principles of the educational process, the «Principle of linking theory and practice», because «practice is the basis of knowledge», which «in a distance learning course is implemented by introducing virtual laboratory work or practical projects into the learning process» [4]. Just as for laboratory and individual practical classes, it is better to work in a «live classroom», but due to circumstances, we must also transfer practical experience to the online format, bringing the conditions of virtual education as close as possible to the experience of interaction with children with special educational needs through the formation of social and emotional intelligence in students, developing critical thinking skills and creating situations of inclusive inclusion in the learning process for the further formation of «unconscious» (automatic) choice of the best ways of adaptation and modification.

We are neither the first nor the last to develop materials for online learning, but we definitely need to ensure that students are emotionally involved in the process, as this aspect has the greatest impact on the formation of inclusive competence. Thus, according to researchers C. Chen and C. Wu, «when developing multimedia materials or video lectures, the affective state (i.e., the emotional state of the learner) should be taken into account. However, how exactly the types of video lectures affect learning efficiency, learner emotions, and sustained attention are rarely empirically studied, the results of which will be a valuable reference for the development of video lectures [5]. In our case, when working with inclusive disciplines, we have the opportunity to get feedback immediately, during discussions (interviewing students) and indirect questionnaires, but in the long run, we will be able to see the results of this approach in a few years, when students who have been trained in an online interactive format according to the scheme of interaction and video project creation we propose, when they start their practical work at school. Their choice of class (regular or inclusive) or rehabilitation facility will determine the quality of the chosen format of interaction during training and its impact on their inclusive competence.

In addition, building basic interaction skills through discussion of a presented video from an inclusive classroom can help to see and review «complex actions from different perspectives», supervise «with more experts and mentors to develop new ways of looking at what they see and experience and conduct «individual and collective reflections can deprive teaching practice and help teachers to change their understanding of teaching [6]. And «although traditionally reflection has been conceptualised as a predominantly individual activity, more recently attention has been paid to the collective dimension of reflective practice» [7]. After all, «involving everyone in a shared reflective dialogue is important for developing a common, agreed understanding of teacher roles, especially where teachers' conceptions of them are changing, as well as for continuously reflecting on and critiquing practice and testing ways of teaching children» [7].

In addition, if there is no possibility to watch a video fragment or video project together, the teacher can supplement the materials of the instructions for completing tasks for further discussion with a separate video commentary and video instructions. Or, upon completion of the task, add feedback, critical commentary and a review of the task to «review the main issues or events in the procedure and give a brief description of how the task is organised; provide a concise repetition or replay, which should help retain memory; give the user a second chance to learn; compensate for any possible wandering of the mind while watching the demonstration; compare the instructor's review with the learner's own summary and, in case of discrepancy or a different viewpoint, this can lead to a second» [8].

Thus, the first stage of collecting and processing information about the possibilities of video projects, their application, creation and discussion resulted in a clear structure for filling the online teaching process with specific content for the speciality of a teacher with inclusive competencies: watching video clips, video projects and online courses, followed by reflection, critical thinking and playful art therapy of the information presented in them.

The result of this information gathering and organisation of the educational process was the determination that our next step would be to introduce the creation of a project within the framework of an educational hackathon, which would be necessarily covered on the Inclusive Education page on the Facebook social network and present the experience and achievements of an individual student or a small subgroup of an academic group in studying inclusive subjects [9].

In addition, in this case, when video projects are created for participation in an educational hackathon, we have the

opportunity to increase the options for evaluating, critically discussing and comprehending the material created by students, taking into account their experience, responsibility and knowledge, skills and abilities. After all, this work has several evaluation options: the grade given by the teacher for the work submitted by the student and the average grade for the work submitted by the student given by other students; the deviation made by the student due to too high or too low grades in the evaluation of other works [10], and the evaluation of experts – invited specialists from various fields related to the topic of video projects and the hackathon itself and the technical side of the project presented - is also taken into account. This allows for a comprehensive approach to the evaluation, providing critical feedback for further reflection on the strengths and weaknesses of the presented work and its information content.

In addition, projects and assignments of this kind, in our opinion, should «encourage student teachers to develop their own professional digital competence» and this, in turn, will contribute to the introduction of «innovative ways of teaching and learning with ICT» [11].

The third equally important step for the students who collaborated in the study of inclusive education courses was participation in a joint international project involving interviews with inclusive education specialists – practicing teachers, assistants in the COIL course. The results of this project will be available in our next publications.

III. Results and discussion

As a result of processing the information that is close to our research question, we came to the conclusion that in order to develop inclusive competence, we have to:

- include a variety of videos in the plan of lectures, practical and laboratory classes, as well as, in some cases, online courses on the main topic of the discipline for self-study;
- make it a rule to create a video commentary on assignments (step-by-step description for quality performance) or watched videos that students have already processed and presented their own summary «critical commentary» for further reflection and discussion;
- to create videos or other types of video products to expand digital education skills and form inclusive competence by taking into account the needs and capabilities of the target audience;
- open access playback of video recordings of online lectures and other pairs for discussion, «recall», introduction of innovations in their own future professional activities;
- participation in interviews and other international projects using video materials and with the possibility of creating such video projects to acquire new knowledge, share experiences and develop technical skills for organising the educational process in distance learning:
- reflection on each stage of the video project creation and the work mentioned above to improve teaching skills, adaptation and modification of the educational space to meet the needs of the child, educational requirements, etc.

IV. Conclusions

Thus, in our opinion, students of pedagogical specialities who will have to work and create an inclusive digital online space in the future need to master the skills of creating and critically evaluating video projects on topics that are close to their future professional activities. After all, such work teaches them to plan their activities not only in time, but also to think through their short-term and long-term goals, to critically reflect on the material presented in the video project, taking into account its main purpose and its inclusive component (the capabilities and needs of students or professionals for whom the content is intended). Of course, the use of existing content, its discussion, presentation and reflection from different perspectives creates the prerequisites for the formation of inclusive competence based on well-developed emotional and social intelligence, critical thinking, which are the primary basis for a pedagogical specialist.

The issue of using video recordings of joint work with students on the formation of inclusive competence as a video project is currently quite controversial for us, because it is «an instantaneous slice of subtle trust in the process of interaction between the mentor of the educational process and its participants» and the removal of certain elements of interaction may negatively affect further work in the classroom or online meeting room. However, at the same time, it will allow us to show another side of the educational process, which is not only playful or «entertaining», but also involves inclusion in the process of cognition with deep immersion in the process of interaction for understanding, rethinking and reproducing an inclusive educational environment in a «regular classroom».

Therefore, our research does not exhaust all the issues faced by teachers of inclusive disciplines and allows us to direct our further search in this direction through the implementation of the following video projects, which are offered both for internal use in the educational process and for the promotion of inclusive education in social networks.

V. Acknowledgments

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practice when working with students of pedagogical specialties in inclusive education and speech therapy.

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Basic Knowledge of Software and Web Content as Elements of Social Programming in Education

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Abstract. **For any specialist, basic knowledge of his or her specialty is like a "daily routine" that should create comfortable conditions for the realization of basic professional tasks. At the same time, the changes brought about by the transition to a remote format of communication, professional activity and the need to use the mechanisms of the information society affect the basic process of socialization, formation and development of personality. This process is part of the educational process - the "knowledge acquisition routine" or social programming that meets the needs of the state, society, national culture, etc. And it cannot have primary and/or secondary aspects.**
That is why the task of our research on this topic is to try to figure out what basic knowledge of software and web content, including programming skills, can be the necessary minimum in teacher training for everyday activities in the digital world (including the needs of society and the interests of children/youth). What should be a prerequisite for quality interaction between teachers, subjects and objects of the educational process in the digital world. In particular, what format, ethical norms and legislative aspects of regulation of the digital educational process, including relevant content, should be the basis for such interaction.

Keywords: education, social programming, software, web content.

I. INTRODUCTION

The digital educational environment is something that sounds like a commonplace today and does not cause a definite «no» from parents and teachers. But at the same time, we, as those who train pedagogical specialists and those who are already involved in this process, need to understand for ourselves what exactly digital transformation in education is. What part of it should become an integral part of the skills of teachers and their students.

In the current realities and flow of information, scholars and practitioners identify «five key areas associated with primarily professional attributes:

1. Communication skills, including language and presentation of ideas.

2. Collaborative skills, including management of group activities and social interaction.

3. Individual learning approaches, including critical thinking, metacognition and new skills acquisition.

4. Individual autonomy, including flexibility, adaptability and entrepreneurship.

5. ICT and digital literacy, including the use of technology as tools for learning, communication and

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collaboration» [1]. Thus, the same authors – C. Joynes, S. Rossignoli and E. Fenyiwa Amonoo-Kuofi – note that «digital literacy in the 21st century context indicates individual confidence in the use of media and ICT and proficiency in the use of digital tools, plus interactive digital skills, critical use of digital tools (analysis, critique, evaluation, creation), and the ability to attend to ethical responsibilities required in participatory culture in technology», which will correspond to «four overarching 21st century competencies' that should be integrated into existing educational systems: lifelong learning, problem-solving, self-management and teamwork» [1; 2], and will also ensure interaction within the «three dimensions for learning in the 21st century: information, communication, and ethics and social impact [1].

This approach is being further developed in the field of education in accordance with the results of the analysis of the current development of ICT in education, in particular, according to the report on Objective 1 «Benchmark progress in ICT in schools», «focusing on: access to and use of digital technologies; digital activities and teachers' and students' confidence in their digital competence; ICT-related professional development of teachers; students' digital home environment and schools' digital policies, strategies and opinions» [3].

As D.Gannon notes, to achieve the main purpose of education in the digital world, «a wide range of software is now available for use in education, including applications that were not specifically designed for the education sector» [4]. In addition, «by using ICT integrating methods and strategies to different aspects of learning one can promote more meaningful and congenial learning environment in terms of active, collaborative, creative, integrative as well as evaluative learning» [5].

And at the same time, when it comes to the possibilities of education in the modern world, we start talking about teachers, educators and professors who must «keep up with the times». In this sense, we need to understand that educators who are not connected to technology and who use the simplest skills are not ready to move to the digital era. After all, they have a shortage of time (sometimes even personal time) in their arsenal of daily tasks and communication with colleagues, students and their families. This also slows down the pace of digitalization of education.

This thesis is supported not only by our research, but also by a similar opinion in various foreign publications, particularly from developing countries. Thus, among the root causes that prevent teachers from fully mastering IT and unlocking its potential in the educational process are: the barrier of budgetary constraints, the lack of Internet access at the workplace, and sometimes even the equipment to demonstrate the necessary materials (projectors, whiteboards, laptops, etc.), it is also important to mention here that various studies have highlighted other barriers such as lack of proper vision and planning as well as social, cultural and political realities. School leaders and teachers' negative attitude towards technology use; lack of knowledge and skills required; time shortage are among the major barriers that hinder the successful use of technological tools that would enhance the attainment of required skills in different work sectors [6].

However, in our opinion, considering the basic terminology and understanding of software from the perspective of non-IT specialists can help teachers feel confident in using technology in the educational process. That is why we have chosen the following as the ***purpose*** of our scientific review: to determine the necessary minimum of basic knowledge of software and web content for a teacher to work in a digital educational environment and its impact on the future generation through social programs that are «approved» by society.

And the main ***objective*** that follows from the purpose of this review is to analyze the terminology and technical software from the point of view of social programming in education and to present pedagogical theory and practice on this issue.

II. Materials and methods

We, like most Ukrainian teachers (who did not study IT specifically), used information technology in the preparation of scientific, educational, theoretical and practical materials in our practice. However, before the challenges posed by the 2019 pandemic, we limited our interaction with technology in the classroom to the results of work in office editors (Word and PowerPoint), and this was sufficient to ensure the quality and effectiveness of the educational process. Students chose whether to prepare with books from the Living Library or from libraries available on the Internet.

At the same time, the changes that education in Ukraine has undergone since 2019 have outlined the need for an «ordinary teacher» to «immerse himself in the digital era and digital learning environment». That is why it was and is a priority for Ukrainian educators to understand what the digitalisation of education is and to find out what basic software they have in their «arsenal».

Therefore, the main methods we used in this study are:

- studying, analysing and summarising information from specialised literature in the fields of IT and education on basic software and web content;
- analysing the interdependence of the concepts of social programming and skills in using software and web content
- highlighting the basic software and web content for developing the skills of a modern teacher in a digital educational environment.

III. Results and discussion

In order, to fulfil the ***research objectives***, we analysed the literature that is currently freely available and turned to

the basic terminology of our study. First of all, we must understand that «software is a set of instructions, data or programs used to operate computers and execute specific tasks. … is a generic term used to refer to applications, scripts and programs that run on a device. … The two main categories of software are application software and system software» [7].

In the scientific and technical community of Ukraine, it is customary to use «*a general concept that describes computer programs as opposed to its hardware components. It does not specify in what form the programmes are presented (in source code or executable code). Software is divided into two broad classes: system software and application software. System software includes any software required for the development and execution of programs, such as operating systems, compilers, debuggers, and so on. Examples of application software include accounting programs, educational programs, computer games, CAD, etc*» [8].

However, it is more relevant for us, educators, to understand the following division of the software offered by D.Gannon in our daily routine of teaching. It is:

Content-free software. «*Also referred to as productivity software, content-free software includes the range of software applications, which may be used in the performance of cross-curricular tasks. Examples of children's use of content-free software include word-processing software to write a report, multimedia authoring or presentation software to create and display work, multimedia software to produce a video clip, concept mapping software to organise ideas, or simulation software to solve a problem in a controlled environment. Software which facilitates the editing of text, pictures, video and sound also comes under the category of content-free software. In this chapter, where the use of software requires or is enhanced by the use of specific input and output peripheral devices (scanner, digital camera, digital projector, digital video, concept keyboard) these devices are included in the discussion for that software type*» [4]. By the way, this is exactly the software that teachers constantly use in preparation for classes and events, their implementation, individual and group consultations, projects, group work, and, importantly, even in the absence of technical capabilities in the educational institution.

Software with rich content that «*refers to applications, that contain specific curriculum content and provide the child with opportunities to engage with this content using tutorials, practice problems, assessments, feedback activities, simulations and so forth. Examples of content-rich software include reinforcement software for revising maths concepts, reference software for researching a topic or idea, and exploratory software for simulating a science experiment*» [4]. This category also seems simple to understand, and this is where the difficulty arises, because at this stage we are already moving to web content, which is inextricably linked to interactive interaction, both in real time and asynchronously, according to the needs and capabilities of the participants in the educational process.

What is web content? According to Ukrainian scholars, the second generation of the web, which arose as a result of the need for interactive interaction among users of Internet services and the emergence of «*new technologies for developing websites and presenting their content that facilitate the dialogic sharing of information, interaction (interoperability) and cooperation on the World Wide Web. Examples of Web 2.0 include: communities built on interaction in the WWW, web services, social networks (Facebook, MySpace, etc.), video hosting (YouTube), wikis (Wikipedia), blogs, mash-ups (mash-ups are web applications that combine data from multiple sources into one integrated tool, thus creating a combination of functionality in one web interface) and folksonomies (folksonomies are systems that allow users to collectively (collaboratively) classify and search for information). Sites in this category allow users to interact with other users or modify the content of websites, as opposed to websites where users are limited to passively viewing information*» [8].

Thus, a teacher who uses web content in his/her practice to interact with students already has the appropriate skills to fulfil the purpose of the digital learning environment, but then a reasonable question arises whether this is enough and at what level these skills should be presented?

Here, we will use a study conducted in Ukraine to help us rank the respondents, which revealed the reasons for the low use of ICT in the educational process in 2016. For example, only 12% of respondents systematically use ICTs, 64% use them occasionally, and 11% do not use them (according to the study, 8% do not use them because they are not available and 3% do not see the need for them), and clarifying questions allowed the authors of the study to identify that the main reason is the lack of high-quality electronic educational resources for educational purposes (74% of teachers) and 5% of respondents indicated that preparing for an ICT lesson takes a lot of time [9]. Thus, three of the previously identified problems of digitalisation of education were identified and confirmed, which also demonstrated the lack of relevant knowledge of basic software and web content that would allow for the rapid creation of non-standard, game-based content for a regular lesson and teachers' own understanding of the benefits of expanding the use of ICT/IT in the educational process and the acquisition of relevant digital skills.

In contrast to this attitude to IT in education, we can note that «*the conceptual shift in the paradigm is due to the transition from a content-oriented approach to a process-oriented one, according to which learning is understood not as the acquisition, accumulation and reproduction of knowledge, but as the formation of the ability to comprehend, explain and interpret it*» [10]

Therefore, a game – game applications, mobile games and applications, online platforms – are becoming an integral part of the educational process and only deepen their impact on the development and formation of the individual, occupying one of the main positions in the formation and development of skills necessary for successful adaptation and socialisation.

Thus, we can move on to ***analyse the interdependence of the concepts of social programming and skills in using software and web content and understand what exactly unites them in the digital educational environment.***

For example, according to V.Terziev research, we consider first of all the interpretation of the term «programme», which usually includes: «*action plan at work; statement of basic principles and objectives of the activity of political parties, organizations or individuals; a summary of the content of a school subject; an ordered sequence for action embodying an algorithm for solving certain tasks*» [11]. Meanwhile, social programme is a promising concept for welfare growth and development of social relations. It gives a general description of the strategy for social development in a particular historical period, the main areas of well-being growth and global qualitative and quantitative indicators to be reached during this period [11].

This is also what the digital transformation in education is striving for. After all, according to the results of the DRIVE LIMITLESS LEARNING project:

«*IT modernization is dramatically changing learning experiences and teaching environments. Digital is also transforming the way institutions of higher education around the world operate. From large research institutions and teaching hospitals to community colleges, digital campus initiatives move academic institutions toward more secure, agile, and cost-effective infrastructure and services, empowering individuals at all levels – from faculty, staff, and administration to that most important stakeholder, the student*» [12].

Such challenges are the driving force for joining forces in education, because the education sector is responsible for implementing «social programmes», state policy on training, retraining and additional education of individuals, who are part of human resources, whose transformation involves acquiring the necessary social skills to ensure the implementation of social policy. And this, in turn, is impossible without «organisational efficiency», which implies the provision of resources, a clearly defined goal as the end result, coordinated with the dynamic social environment, the achievement of which will be based on the choice of an appropriate strategy that will contribute to the achievement of the intended end result [13].

In addition, social programming proper, which is seen as the process of the state's deliberate use of a set of specific methods and means of influencing human consciousness in order to shape or re-shape the consciousness of an individual as a member of society in a certain direction [14], is the deliberate inclusion of an individual as part of society and/or a certain social group in these processes in order to achieve a general purpose.

In our case, all of this should be united by one purpose – the training of a specialist teacher who has the knowledge and skills to use basic software and web content to implement state policy aimed at achieving effective social integration and self-realization of the individual for the welfare and prosperity of each «element» of the state and society.

IV. CONCLUSIONS

So, based on the above, from the theoretical and practical aspects related to the basic knowledge of software and web content, we have come to the following conclusion.

In order to implement the state policy and achieve the main goal of education in the digital educational environment and information technologies, we must provide training and retraining of pedagogical specialists in accordance with the following three levels.

The first level is the user educator, who can perform simple tasks such as preparing materials, providing online learning based on materials that have been transferred to a text editor or created a presentation, sending emails or creating chats with students, creating an online conference and demonstrating presentation materials.

The second level is the innovator teacher, who can use basic software and web content to create non-standard, creative solutions for presenting new material, learning the material studied, connecting game exercises that would be consistent with the gamification of education from already created content, choosing proven, adapted and high-quality game platforms and applications.

The third level is that of the developer, who not only uses developed and available game elements, but also develops them, supplements, improves, and engages children in creating their own content with high-quality, verified information that will work in the long term.

This is the level of teacher training that should be designed for today, because it is not only a challenge of the modern world, it is a digital necessity of the reality in which the digital educational environment operates.

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Basic Principles of Using Virtual and Augmented Reality Technologies in the Process of Teacher Training in Ukraine

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Abstract. **In our opinion, in all aspects, education should correspond to the modern realities of the world, for life and communication with which we prepare a person. We propose to pay attention to the preparation of the individual, because without the readiness of the teacher to fulfil his or her responsibilities for socialization and development of skills necessary for self-realization, we lose not only a favourable period. We lose time and opportunities for a person's success in life.**
For example, teachers' lack of skills or knowledge of currently popular audio-visual content programs, building effective communication in social networks, and their quality use in the educational process create a «generation gap». After all, «gaps» in the knowledge, skills, and capabilities of a teacher or professor are immediately «striking» to children and young people, causing them to reject the teacher's personality and, as a result, the information they broadcast.
In addition, a modern young person, fascinated by the possibilities of gadgets and gamification in education, constantly needs new impressions, sensations that will allow them to engage in the educational process, and will interest young people who are oversaturated with various types of information. That is why, in this review, we outlined the main points of our use of currently available virtual and augmented reality technologies, in particular the AltspaceVR program, in the practice of training primary school teachers. We also presented our experience and various aspects of using these technologies in the Ukrainian educational space.

Keywords: AltspaceVR, augmented reality, educational technology, virtual reality, teacher training.

I. INTRODUCTION

We would like to start our research with a quote from: «*Current development of digital society is based on improvement of information technologies and their introduction in all industries. In the source [1] term «digitalization» defines process of saturation of the physical world by electronic-digital devices, facilities, systems and establishment of electronic-communication exchange between them, which in fact makes possible to integrate virtual and physical and to create cyber-physical space. Main purpose of digitalization is to achieve digital transformation of existing and creation of new industries, as well as transformation of life spheres into new more efficient and modern ones*» [2].

The same applies to the most sluggish sphere of education (for Ukrainian society, according to our subjective assessment). After all, we must not only move to new components of teacher training for different levels of education (preschool, primary, secondary or basic, higher), which will influence the «intellectual development» of a child or teenager in the future. In particular, the formation of skills and readiness to use high-quality educational content and its creation in the digital world. But we, the teachers who train future educators, also need to become more comfortable with IT.

And in this we fully agree with the thesis «*I think in this case it is a whole new field and I think that there is a lot for all of us to learn*» [3]. And this applies not only to the digital world around us, to digital education, it is something that is growing as a problem of understanding the transformed demand of modern students, i.e. «*Young people want to build their individual learning trajectory by choosing both academic and non-academic courses; both offline and online [4]*» [5]. That is why, according to the team of authors, «*teachers often use the method of educational projects to further interest students in the*

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university» [5]. This has not escaped our interaction with higher education students.

But before we move on to the project that was «completed», we would like to draw your attention to a few points.

Firstly, «*virtual reality (VR) has been around for many years... The high price, complex technology, and lack of accessibility have made it unattractive to many educators... Nevertheless, in 2017, full immersion VR became mainstream with the Oculus Rift [6]. The emergence of this more accessible VR device*» can allow for high results in virtual interaction «*regardless of technical background, as long as a support team is present to train participants and monitor progress during such recordings*» [7]. We fully agree with this, as we ourselves had the opportunity to participate in the mentoring programme and, with the support of the programme's teachers, to hold our own event.

Secondly, «*virtual and augmented reality technologies occupy an important place in the new stage of innovative development of the society, named Industry 4.0. These technologies posses both common and distinctive features, which are reflected in the specifics of their use by companies in process of relevant products creation. Virtual and augmented- reality technologies involve creation of thematic visualized content that can be used by intended audience to meet specific needs through modern electronic devices. Presented technologies are implemented in production processes, in marketing companies, in medical sphere, in educational processes, etc. In Ukraine, virtual reality technology is more common than augmented reality [8]*» [2].

Thirdly, it is the experience that mentors and future users should gain related to the skills of «using libraries», which is a «*basic skill needed in today's information society, and is considered a basic literacy-related skill*» [3]. And in our case, it is a basic competence that allows not only to develop skills, but also to ensure a high-quality search for «suitable materials» for working with children with special educational needs, to model and find solutions for interaction between different participants in the educational process, and to find the necessary points of contact to realise the potential of each student.

This approach should be basic, because based on the skills of searching for and adapting information, a future teacher can choose which tool to use to work with a particular group of children.

For example, when choosing augmented reality (AR), we should understand that «*is an advanced technology that merges elements of a physical real-world environment with virtual computer- generated imagery» [9]. Thus, AR allows users to interact with two-dimensional (2D) or three-dimensional (3D) virtual objects integrated with a real-world environment*» [10].

But if we take the simplest tools available to a teacher who does not have technical skills, we can see the following. In total, we counted 34 children's books of various content, form and content and 2 augmented reality board games that are currently available in Ukrainian bookstores (Russian-language content has been removed due to military aggression). In addition, these are quite expensive products that can only be afforded by a «part of the population» of Ukraine and individual libraries participating in various projects. Therefore, this type of product can only be shown to students in an online format, especially when it comes to online learning, when there is no opportunity to meet either in a library or a bookstore for «live communication with the source of information - a book».

However, quite a few authors «*highlight the need to use AR technologies in education because it can provide modern education with new didactic measurements and tools, will facilitate the co-creation of students and teachers, contribute to a better understanding of subjects, visualize hidden processes, and make it acceptable for adults and people with disabilities. The researchers define an AR textbook as a new educational tool which can contain fragments of video lectures, electronic pads (for example, Padlet), augmented quizzes, 3D models, animated tours in the history of the studied problem, in-depth exercises, didactics games etc*» [11].

We partially agree with the above, noting that there are more AR options, but… AR is something that «catches the eye of the teacher», as it is the most familiar and does not require serious training and additional efforts.

At the same time, we understand that the first thing that «catches the eye of young people» is virtual reality (VR) technology. «*This is a system that allows you to 'move' a person into a simulated virtual world», and «immersion in a virtual environment makes the communication process much easier, because it is a spatial spectacular form in which each user-visitor can create not only their own image (choice of gender (!), anthropometric data, clothes), but also to form/choose the environment for virtual stay and virtual communication [12]*» [13], which became an invaluable achievement for the Ukrainian teacher-innovator «*during the 2020 pandemic, where the virtual environment has fully become a communication tool*» [13].

At the same time, we should keep in mind several prerequisites for the success of the latter technology – «*stand-alone head-mounted displays, quality over quantity, recognition of the complexity, educating the educators and social VR*» [14], as well as what users themselves highlight. These are «*full body mirroring activities, doing mundane and essential everyday activities in new ways, activities for social and mental self-improvement, immersive cultural appreciation and educational activities, and engaging in immersive event*s» [14].

And we, as teachers who prepare future teachers, are interested in technologies that influence «*increased interest in learning, high level of understanding and persistence in learning, high learning achievement, improved laboratory skills, positive attitude of students towards laboratory work, effective improvement of visual thinking skills, greater enthusiasm*» [15].

II. MATERIALS AND METHODS

That is why, after analysing the scientific research, we turned to a ***topic*** that was close to us and could not only «catch» the student, but also create conditions for the development of his skills in the digital educational environment, which can be directly used in practice. In fact, this and the above defined the main task for the research on this topic.

The ***task*** is to present the inclusive component of teacher competencies in the digital educational space, which will «smoothly» move from passive student skills to active skills during their own professional activities

This contributed to the planning of involving 2nd year bachelor's degree students taking the course «Special Pedagogy» in the final stage of presenting the results of participation in the Mentoring programme of the Media Literacy Workshop «New tool - new opportunities: meet AltspaceVR» 3.0!

III. RESULTS AND DISCUSSION

As part of our cooperation with the participants of the Ukrainian project «Study and Distinguish: Infomedia Literacy», we had the opportunity to attend events held by colleagues from different cities of Ukraine as part of the Mentoring programme of the Media Literacy Workshop «New tool - new opportunities: meet AltspaceVR» 3.0! There were thirteen events in total, organised by school teachers and university professors. The results of this programme are available on the Mentor Programme channel [16].

At the same time, we also joined a similar event with our audience of 2nd year bachelor's degree students who were taking the Special Pedagogy course. A total of 26 people took part in this course. Students were invited to join a «journey» through the virtual world. To do this, we developed 5 lessons within the discipline step by step:

1. The first meeting. Acquaintance and setting up for work in VR space, explanation of the differences between virtual and augmented reality, a brief history of the development and features of virtual reality in the modern world, as well as a discussion on the possibilities and «dangers» of using this technology to implement the tasks of inclusive education (7 December 2021).

2. The second meeting (10 December 2021) was devoted to the technical side of interaction with the virtual space in the AltSpaceVR programme, connecting, and troubleshooting connection problems.

   Overall, «*AltspaceVR is one of the first social VR platforms of the modern virtual reality era. AltspaceVR is a free virtual reality platform that can be used in 2D mode (without glasses) from a computer or laptop*», and to work in the program, the computer must meet the specific characteristics of «*64-bit version of Windows 10*» [17].

   Therefore, there were enough «problems» and we listed these problems in separate publications (not related in particular to the program, but only to the availability of equipment or a stable connection to the Internet).

   But the main and first problem was «low-quality software», i.e. pirated or «limited» copies of the Windows operating system. The second biggest problem of our VR trip was the high «load» of laptops, which meant that we had to wait a long time for the application to load and for the group members to connect to our virtual room. And, perhaps, the biggest «indignation» among students was the fact that this application was not available on other gadgets, so only a few were able to use it.

   Thus, out of 26 students in the group, only five were able to log in, register and try the journey for the first time in a pair. Their task of «super-high» difficulty was to go through several «worlds» and take a selfie in one of them.

3. The next meeting was devoted to learning the main «moves» that we needed during the final event of the project. This meeting took place on 13 December 2021 and provided an opportunity to discuss the «injustice of this world» and talk about the feelings of participants who were unable to join our trip due to technical «inaccessibility», which coincided with the topic of our class on the accessibility of educational space for different categories of children with special educational needs. In addition, we were able to relieve the psycho-emotional stress of those participants who were unable to due to the lack of equipment that would meet the parameters of the AltSpaceVR application. After all, even the fact that we demonstrated the screen of a teacher who was working with students in the app in parallel did not give a «full sense of involvement in the journey». Although, such a double demonstration created a temporary effect of presence. But, at the same time, it limited the participants of the online meeting in Google Meet to be observing and discussing what was happening on the screen.

4. At the fourth test meeting on 14 December 2021, seven representatives of the group were able to «break through» into the VR audience. They also took part in the final event, which we reported to as part of the Mentor Programme. Here we had 3 rooms with transitions between them through teleportation, buttons with questions on inclusive topics.

5. The final event with representatives of the Inclusive Education Final Camp mentoring programme took place on 20 December 2021. The event was attended by 7 students and 4 mentors of the programme. The event was unofficially called the «Rat Race» because it was built in the format of a competition, where students and guests (by the way, we also had foreigners who were watching and looking at the world we created) had to choose an answer. And depending on whether it was the right answer or not, they either got to the next stage of the event with questions, or they were thrown out into the previous room, or even into a «clean space» (tabula

rasa). In the case of the latter, the participants had to re-enter the room code they remembered last and go all the way from the point of return to the game.

At the same time, the students who remained «out of the game» also had their own task - to keep track of the questions and write a critical comment and feedback on the rooms and the goals that each of them pursued. In addition, the 19 students' attention was held by the fact that, in addition to observing, they watched video clips with the VR users and left correct (in their opinion) answers in the chat.

Thus, despite the limitations artificially created by the students' technical capabilities, we were able to give them a sense of involvement in the race process. Of course, at the end of the project, in the absence of the guests, we discussed the issues that arose during the video and game questions at the next meeting.

In this way, we were able to implement not only the project's intention, but also to demonstrate and engage the future generation of primary school teachers with a specialisation in inclusive education in modern technologies of inclusion in the educational process through VR.

IV. Conclusions

To summarise the theoretical work done to find the background of introducing virtual reality into the educational process or vice versa, we can note that this is basic information that students of our specialisation should know, but not necessarily. As for the practical component, today this audience of students is more involved in the process of using online games, simulations and simple test tasks than those who have not taken this course. In addition, this gives future professionals an advantage over others, as they can consciously discuss ethical, technical and other issues of interest to children of primary school age (who today have a fairly high level of skills in using gadgets to develop their soft skills) with children of primary school age. This will help to overcome the «generation barrier» and act as a mentor rather than a teacher in the educational process, ensuring its inclusiveness even in the digital educational space.

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Organization of Student-Oriented Pedagogical Studies: Analysis of Students Learning Experiences

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Abstract. With the development of technology, the organization of pedagogical studies is increasingly taking place in a mixed way, when studies in a real classroom are combined with learning in a virtual learning environment. However, regardless of the tools or resources used in the virtual learning environment, for the organisation of student-centred studies the pedagogical aspect remains essential. This need is highlighted in the Lithuanian and European Union documents. The research aim is to analyse the learning experience of pedagogical students. Methods of research: analysis of scientific literature, survey, descriptive statistics, and inference statistics. The article reveals Primary Pedagogy and Early Childhood Pedagogy students' learning experiences in the following aspects: relevance of learning, reflective thinking, interpretation the study process, interacting with the tutor and with peers. The results of a quantitative study (survey) showed that the relevance of learning, reflection and interpretation of the study process depends on the study methods used, the support provided by the tutors and peers.

Keywords: interactivity, methods of study, reflective thinking, students of pedagogical studies.

INTRODUCTION

Examining both the world [1], [2] and National Education Regulations documents [3], [4] noted that more and more talk is being made about the need to enable learners to feel the relevance of learning, to reflect and interpret the learning process, to interact with the tutor and other learners in solving real-life problems.

For students to understand the relevance of learning, theoretical studies must be applied in practical activities [5]. Solving real-life, relevant, and understandable problems encourages students to interact with the tutor and peer by exploring, raising hypotheses, and developing new products [6], solving and interpreting real-life problems [7]. The involvement of students in the learning process and its reflection makes it possible to develop a sense of responsibility and understand the meaning of self-development, which is a clear prerequisite for improving lifelong learning abilities [8]-[9].

The organization of studies is increasingly taking place in a mixed way, combining studies in real-life classrooms and learning in a virtual learning environment [10]. However, regardless of the virtual learning environment tools or resources used, the pedagogical dimension always remains essential. In this context, the problem question of the research is formulated – how the student-centred pedagogical study process should be organised enabling the learner to understand the relevance of learning, reflect and interpret the study process, and interact with tutor and peer in solving real life problems. Research subject is the learning experience of pedagogical students. The research aim is to analyse the learning experience of pedagogical students. Methods of research: analysis of scientific literature, survey, descriptive statistics, and inference statistics.

LITERATURE REVIEW

In order to successfully solve problems and evaluate ongoing phenomena, it is important for the learner to understand the relevance of learning [11], to be able to reflect on the learning experience [12], to interpret, analyse and evaluate information, to draw conclusions [13], to initiate multilateral interaction among learners, to feel the support provided by the tutor and other learners [14]. It is important to discuss the following components of the

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learning process: relevance, reflective thinking, interpretation, interactivity, tutor support and peer support [15]. These components of the learning process will be briefly discussed below.

Relevance. Often, learning success is judged by the number of correct answers that learners can simply remember [16]. However, learning involves not only remembering of facts and concepts, but also combining them in such a way that the new concepts of the subject are related to those previously learned [17]. The learner must understand the applicability of theoretical knowledge in practice [5].

Reflective thinking. The main pedagogical goal is to engage students in collaborative learning and reflection on the learning process [18]. Reflective thinking focused on the essence of thinking, what to believe or what to do [8]. Reflection on the teaching and learning process is the basis of metacognitive teaching, therefore, when assessing student learning achievements, it is important that each stage of learning process is reflected [12].

Interpretation. Students' thinking is developed by introducing them to the hierarchical structure of knowledge characteristic of the learning subject, paying attention to the clarifying meaning of the subject in practical activities [19]. Therefore, it is recommended to encourage students to explain the concepts of learning subject, understand their meaning from the context, and interpret the obtained results in a real-life context [7].

Interactivity. It was established that students' achievements depend not only on educational context, pedagogical interaction, but also on the teacher's innovation and creativity to manage the educational process professionally [20]. Solving real-life problems helps to initiate multilateral tutor and peer interaction, an ability to ask or understand questions [9]. It is proposed to organise the educational process in such a way that students acquire knowledge and abilities through practice and interacting with tutors and peer [21].

Tutor and peer support. It is noted that more and more attention is paid to solving problems while working in a team, when students discover scientific truths themselves with the help of a teacher and peer [22]. Thinking through communication and collaboration involves supporting students' ideas, forming a common understanding and goals of the group [23]. Such experiences are beneficial because students can learn from other learners.

Teaching and learning using computer technologies provides an opportunity to connect to remote data sources and allow communication and collaboration with remote students or a teacher [9], transfer traditional learning methodologies to a virtual learning environment, develop new learning methodologies [24]. In virtual learning environments, teachers become facilitators for students [25], engaging students in virtual collaboration and participation in discussions [26].

RESEARCH METHODOLOGY

To determine the learning experience of pedagogical students, a group of subjects was formed using availability sampling, where the general sample units are included in the sample that are most accessible to the researcher. The sample size (n = 231) was determined using the Paniotto single-level randomisation formula. Participants of the research (n = 231) are students of primary education pedagogy (PPE) (n = 103) and students of early childhood education (ECE) (n = 103).

Pedagogical studies are organised in a mixed way. Contact work takes place both in an auditory and virtual learning environment Moodle. A survey based on the Constructivist On-Line Learning Environment Survey (COLLES) was adapted for the study. Considering the specifics of pedagogical studies, the survey was supplemented with two questions about motivation to study pedagogy and study methods. The research was conducted in November 2022 using the virtual survey tool https://apklausa.lt.

The research data were analysed according to four categories: 1) study program (PPE and ECE); 2) nature of funding (state-funded and students who pay for studies); 3) form of study (full-time, full-time session and part-time); 4) study course (the first, second, third and fourth).

The research data were also analysed according to the following parameters: motives for studying pedagogy, study methods, study relevance, reflective thinking, interactivity, teacher support, peer support.

The normality of the variable distribution was tested using the Shapiro-Wilk test. Zero hypothesis (H0): the distribution of variable data is consistent with normal distribution. Alternative hypothesis (H1): the distribution of the variable does not correspond to the normal distribution. The Mann Whitney and Kruskall-Wallis criteria were used for data that were not distributed according to the normal distribution. Throughout the research, decisions are taken at a value $\alpha = 0.05$.

To establish the correlation between study methods and study relevance, reflective thinking, interactivity, tutor support and peer support, the Spearman's Rank correlation coefficient was used. To answer the question of whether these values are linearly dependent, the hypothesis about the equality of Spearman correlation coefficient to zero has been verified: Ho: $\rho = 0$; Ha: $\rho \neq 0$. The survey data was processed using version 27 of the IBM SPSS Statistical Package for Social Sciences.

Research ethics. Research adhered to the fundamental principles of the European Code of Conduct for Research Ethics [27]: reliability, integrity, respect for colleagues, responsibility for research. The author of the study undertook to publish only the aggregated data of the study.

The internal consistency of all the questions in the survey was verified by calculating the Cronbach alpha coefficient.

RESEARCH RESULTS

Motives for studying pedagogy. The following motivations for studying pedagogy of PPE and ECE students were analysed: good feedback of graduated students, willingness to work with children, guaranteed work, financial support, presentation of the pedagogical study programme during career days, media, formation of practical skills during studies, relevant specialisations, low entrance competitive score for university.

The Mann-Whitney test showed a statistically significant difference in two cases: good feedback of graduated students (U = 5622.5, Z = 3.092, p = 0.002, r = -0.203) and formation of practical skills during studies (U = 4818.5, Z = -4.577, p = 0.00, r = -0.301). The motive "Formation of practical skills during studies" for state-funded students (U = 1402.50, Z = -2.774, p = 0.006, r = -0.183) is stronger than students who pay for studies (U = 1019.50, Z = -3.703, p = 0.00, r = -0.244). The motive "Good feedback of graduate students" for full-time session state-funded students (U = 113.00, Z = -2.688, p = 0.007, r = -0.177) is stronger than students who pay for studies (U = 21.50, Z = 2.347, p = 0.007, r = 0.154). For PPE students both motives are stronger than for ECE students.

Study methods. The following study methods were analysed: analysis of literature, analysis of situations, case study, creative tasks, debates, demonstration, document analysis, educational games, educational trips, essay preparation, folder method, interactive lecture, mind (concept) map, overview of information sources, project activities in groups, reflection of experience, watching and discussing the film, work in groups, work with visual industries, working with the dictionary.

The Friedman test showed a statistically significant difference (χ^2 = 861,392; df = 19; p = 0.000) between the study methods used. A comparison of Mean Rank shows that the following study methods are most used in the study process (Table 1).

TABLE 1 STUDY METHODS. FRIEDMAN TEST

Study methods	Mean Rank
Work in groups	15,76
Project activities in groups	13,25
Creative tasks	12,90
Reflection of experience	12,17
Analysis of literature	11,48
Essay preparation	11,13
Work with visual industries	10,83
Document analysis	10,74
Folder method	10,52
Analysis of situations	10,39
Overview of information sources	10,35
Demonstration	10,26
Case study	10,00
Educational games	9,87
Mind (concept) map	8,92
Working with the dictionary	8,66
Watching and discussing the film	8,62
Interactive lecture	8,49
Educational trips	7,93
Debates	7,71

The following study methods are more often used when working with EPP students than with ECE students: work with visual industries, document analysis, folder method, demonstration, educational games, mind map, work with vocabulary, interactive lecture, study trips, debate. However, experience reflection, case analysis and project groups methods are more often used when working with ECE students than with EPP students. The demonstration study method is more often used when working with part-time PPE students (Mdn = 62.36, n = 11) than with ECE students (Mdn = 47.29, n = 86).

The following study methods are more often used when working with full-time EPP students than with ECE students: folder method, document analysis, interactive lecture, mind map and educational games. However, case analysis and study trips are more often used when working with ECE students than with PPE students.

Relevance. Four relevance statements were examined: my learning focuses on issues that interest me; what I learn is important for my professional practice; I learn how to improve my professional practice; what I learn connects well with my professional practice [15].

The Spearman test was used determined that the studies for PPE students are relevant when learning is focuses on students' interest and what they learn are connects with their professional practice. It depends on the following methods of study: creative tasks (r = 0.337), demonstration (r = 0.291), educational games (r = 0.262), mind maps (r = 0.236), project activities in groups (r = 0.215), work with visual industries (r = 0.212). For ECE students what they learn is important for their professional practice and they learn how to improve professional practice. It depends on the following methods of study: watching and discussing the film (r = 0.219), creative tasks (r = 0.224), project activities in groups (r = 0.265) and debates (r = 0.204), reflection of experience (r = 0.207).

The Mann-Whitney test was used to determine the attitude to study relevance state-funded students' and students who pay for studies. There was a statistically significant difference in two cases: what I learn is important for my professional practice (U = 5583.000, Z = -2.466, p = 0.014) and I learn how to improve my professional practice (U = 5600.00, Z = -2.343, p = 0.019). These relevance statements are more important for state-funded students than for students who pay for studies.

For part-time ECE students what they learn is more important for their professional practice than for PPE students. However, for first-year PPE students this study relevance is more important than for ECE students. It is likely that this is due to the provision of pedagogical support (EUR 299) to PPE students.

Reflective thinking. Four reflective thinking statements were examined: I think critically about how I learn; I think critically about my own ideas; think critically about other students' ideas; I think critically about ideas in the readings [15].

Using the Spearman test, it is established that both PPE and ECE students reflect on the study process when they think critically about how they learn, about their own ideas and about ideas in the readings. It depends on the following methods of study: educational trips (r = 0.316), creative tasks (r = 0.298), demonstration (r = 0.261), debates (r = 0.229), interactive lecture (r = 0.224), work with visual industries (r = 0.218), folder method (r = 0.211). The methods used for literary analysis (r = 0.265) and essay preparation (r = 0.231) have influenced ECE students think critically about other learners' ideas. There was a weak correlation between student study relevance and their thinking critically about how they learn ($0.203 < r < 0.285$). It depends on the following methods of study: interactive lecture (r = 0.221), creative tasks (r = 0.217), educational trips (r = 0.243).

The Mann-Whitney test was used to determine the reflective thinking experience of state-funded students' and students who pay for studies. Students who pay for studies (Mdn = 125.26, n = 121) think more critically about how they learn than state-funded students (Mdn = 105.81, n = 110). This difference is statistically significant (U = 5534.500, Z = -2.321, p = 0.000, r = -0.020).

The Kruskal-Wallis test was used to examine the reflective thinking experience of students studying in the full-time, full-time session and part-time form of study. There was a statistically significant difference in three cases: I think critically about how I learn ($\chi^2 = 8.632$; df = 2; p = 0.013); I think critically about my own ideas ($\chi^2 = 11.543$; df = 2; p = 0.003); think critically about other students' ideas ($\chi^2 = 13.895$; df = 2; p = 0.001). Full-time students think more critically about how they learn (Mdn = 129.22, n = 68) than full-time session students (Mdn = 97.72, n = 66) or part-time students (Mdn = 119.17, n = 97). However, part-time students (Mdn = 128. 97, n = 97) think more critically about other students' ideas than full-time students (Mdn = 129.95, n = 68) and full-time session students (Mdn = 93.94, n = 66).

Interpretation. Four interpretation statements were examined: I make good sense of other students' messages; other students make good sense of my messages; I make good sense of the tutor's messages; the tutor makes good sense of my messages [15].

Applying the Spearman test, it is established that during the studies other learners make good sense of PPE and ECE students' messages and students make good sense of the tutor's messages. It depends on the following methods of study: demonstration (r = 0.299), work with visual industries (r = 0.298), working with the dictionary (r = 0.283), creative tasks (r = 0.272), watching and discussing the film (r = 0.265), reflection of experience (r = 0.264), work in groups (r = 0.263), document analysis (r = 0.252). PPE students emphasise, that using of project activities in groups (r = 0.317), creative tasks (r = 0.263), analysis of situations (r = 0.256) study methods enable the tutor makes good sense of students' messages. There is determined a weak correlation between the PPE and ECE students' studies interpretation abilities and the following components of the study process: of motive to study pedagogy due to willingness to work with children ($0.211 < r < 0.274$); of motive to study pedagogy due the formation of practical skills during studies ($0.210 < r < 0.238$); of studies relevance ($0.257 < r < 0.387$) and reflective thinking abilities ($0.257 < r < 0.387$).

Using the Mann-Whitney test, it is established (U = 5635.500, Z = -2.882, p = 0.000, r = 0.037), that the tutor more makes good sense messages of ECE students (Mdn = 123.47, n = 128) than of EPP students (Mdn = 106.71, n = 103).

The Mann-Whitney test was used to determine study interpreting abilities of state-funded students and students who pay for studies. State-funded students make more good sense of other students' messages (U = 5363.500, Z = -2.773, p = 0.006) and make more good sense of the tutor's messages (U = 5667.000, Z = -2.067, p = 0.039) than the students who pay for studies (U = 5534.500, Z = -2.321, p = 0.000, r = -0.020). This difference is statistically significant.

Interactivity. Four interactivity statements were examined: I explain my ideas to other students; I ask other students to explain their ideas; other students ask me to explain my ideas; other students respond to my ideas [15].

Using the Spearman test, it is established that both PPE and ECE students explain their ideas to other learners during work in groups (r = 0.263) and debates (r = 0.257). PPE students explain their ideas to each other performing creative tasks (r = 0.295), during educational trips (r = 0.294) and during work in groups (r = 0.268). There is a weak correlation between the PPE and ECE students' interactivity during studies and choose to study pedagogy due to willingness to work with children ($0.207 < r < 0.271$), relevance of study ($0.207 < r < 0.382$), reflective thinking ($0.217 < r < 0.318$) and abilities of interpretation ($0.225 < r < 0.458$).

The Mann-Whitney test found (U = 5635.500, Z = -2.882, p = 0.000, r = 0.037), that students respond to the ideas of other students. This ability for ECE students (Mdn = 124.60, n = 128) is stronger than for PPE students (Mdn = 105.32, n = 103).

The Kruskal-Wallis test was used to examine the interactivity experience of students studying in the full- time, full-time session and part-time form of study. There was a statistically significant difference in only one case „I explain my ideas to other students' ($\chi^2 = 20.611$; df = 2; p = 0.000). Full-time students, when they work in groups, more explain their ideas to other students (Mdn = 138.30, n = 68) than full-time session students (Mdn = 88.59, n = 66) or part-time students (Mdn = 119.02, n = 97).

Tutor support. Four tutor support statements were examined: the tutor stimulates my thinking; the tutor encourages me to participate; the tutor models' good discourse; the tutor models critical self-reflection [15].

Using the Spearman test, it is established that both PPE and ECE students argues that the tutor stimulates their thinking, encourages them to participate in the study process, models good discourse and critical self-reflection using these study methods: creative tasks (r = 0.452), debates (r = 0.400), interactive lecture (r = 0.382), case study (r = 0.366), educational games (r = 0.335), watching and discussing the film (r = 0.330).

There is determined a weak correlation between tutor support and the following components of the study process: of students' motive to study pedagogy due the formation of practical skills during studies ($0.281 < r < 0.331$); of studies relevance ($0.237 < r < 0.442$), of students' ability think critically about how they learn ($0.297 < r < 0.377$), of students' abilities of study interpretation ($0.272 < r < 0.562$), of interactivity during studies ($0.229 < r < 0.316$).

Using the Mann-Whitney test, it is established (U = 5334.000, Z = -2.649, p = 0.008, r = -0.174), that the tutor encourages students to actively participate in the study process. This ability for PPE students (Mdn = 128.21, n = 103) is stronger than for ECE students (Mdn = 106.17, n = 128).

The Mann-Whitney test was used to determine the tutor support for state-funded students and students who pay for studies. There was a statistically significant difference between 2 statements: the tutor encourages me to participate (U = 5216.000, Z = -3.015, p = 0.003) and the tutor models critical self-reflection (U = 5338.00, Z = -2.753, p = 0.006). In both cases, for state-funded students the mentioned tutor help is more important than for students who pay for studies.

The Kruskal-Wallis test was used to identify tutor support for first, second, third-and fourth-year students.There was a statistically significant difference between 2 statements: the tutor stimulates my thinking (χ^2 = 8.854; df = 3; p = 0.031) ir the tutor models' good discourse (χ^2 = 10.293; df = 3; p = 0.016). In both cases, first-year students more than other course students feel that the tutor stimulates their thinking and models' good discourse.

Peer support. Four tutor support statements were examined: other students encourage my participation; other students praise my contribution; other students value my contribution; other students empathise with my struggle to learn [15].

Using the Spearman test, it is established that both PPE and ECE students indicate that other learners encourage their participation in the study process and praise their contribution during interactive lecture (r = 0.316), project activities in groups (r = 0.314), educational games (r = 0.291), in case study (r = 0.25) and working with visual industries (r = 0.233). PPE students feel other learners value their contribution doing creative tasks (r = 0.260) and project activities in groups (r = 0.285). Students of ECE arguments, that other learners empathise with their struggle to learn when they work with visual industries (r = 0.245), watch, and discuss the film (r = 0.276), reflect an experience (r = 0.231).

Using the Spearman test, it is established a weak correlation between the peer support and PPE and ECE students choose to study pedagogy due to formation of practical skills during studies ($0.257 < r < 0.289$), study relevance ($0.229 < r < 0.450$), of critical thinking about how students learn ($0.298 < r < 0.378$), of critical thinking about students ideas in the readings ($0.20 < r < 0.245$), of interpretation of study ($0.258 < r < 0.432$), interactivity during studies ($0.263 < r < 0.527$) and tutor's support ($0,354 < r < 0.509$).

The Mann-Whitney test was used to determine the experience of Peer support of state-funded students and students who pay for studies. State-funded students (Mdn = 124.24, n = 121) more feels other students encourage their participation in the study process than students who pay for studies (Mdn = 106.94, n = 110). This difference is statistically significant (U = 5534. 500, Z = -2.321, p = 0.000, r = -0.020).

CONCLUSIONS

Motives for studying pedagogy. The analysis of quantitative research data revealed that good feedback of graduated students and formation of practical skills during studies were the main reasons for choosing to study pedagogy. For PPE students both motives were stronger than for ECE students.

Methods of study. The following study methods are most used in the study process: project activities in groups, experience reflection, work with visual industries, document analysis, folder method, demonstration, case analysis, educational games, mind map, work with vocabulary, interactive lecture, study trips, debate.

Relevance of study. For students' studies are relevant when theirs learning focuses on issues that interest, what they learn is important for their professional practice, when they learn how to improve their professional practice and what they learn connects well with their professional practice. It depends on the following methods of study: creative tasks, demonstration, project activities in groups, educational games, mind maps, watching and discussing the film, work with visual industries, reflection of experience, debates.

Reflective thinking. Both PPE and ECE students reflect on the study process when they think critically about how they learn during educational trips, interactive lecture, debates, work with visual industries, doing creative tasks, demonstrating completed tasks. Students who pay for studies think stronger critically about how they learn than state-funded students. Full-time students think more critically about how they learn than full-time session students or part-time students. However, part-time students think more critically about other students' ideas than full-time students or full-time session students.

Interpretation. Both PPE and ECE students make good sense of the tutor's messages when working in groups, with the dictionary, visual industries, doing creative tasks, watching, and discussing the film, demonstrating completed tasks, reflection of experience or analysing documents. The tutor more makes good sense messages of ECE students than EPP students. State-funded students make more good sense of other students' messages and the tutor's messages than students who pay for studies.

Interactivity. Both PPE and ECE students when they work in groups explain their ideas to other learners during work in groups and debates. PPE students explaining their ideas to each other doing creative tasks, on educational trips and work in groups. ECE students more respond to other students' ideas than PPE students. Full-time students more explain their ideas to other students than full-time session students or part-time students.

Tutor support. Both PPE and ECE students argues that the tutor stimulates their thinking, encourages them to participate in the study process, models' good discourse and critical self-reflection using these study methods: creative tasks, debates, interactive lecture, case study, educational games, watching and discussing the film. The tutor encourages PPE students to participate in studies process and models' critical self-reflection more often than for ECE students. In both cases, for state-funded students the mentioned tutor help is more important than for students who pay for studies. First-year students more than other course students feel that the tutor stimulates their thinking and the tutor models' good discourse.

Peer support. Both PPE and ECE students indicate that other learners encourage their participation in the study process and praise their contribution during interactive lecture, project activities in groups, educational games, in case study and working with visual industries. PPE students feel other learners value their contribution doing creative tasks and project activities in groups. ECE students' arguments, that other learners empathise with their struggle to learn when they work with visual industries, watch, and discuss the film, reflect an experience. State-funded students more feels other students encourage their participation in the study process than students who pay for studies.

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Using Communication and Collaboration Tools in Virtual Learning Environments Moodle for Mathematics in Primary School

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Abstract. With the advancement of information and communication technologies, teaching mathematics in a real-life classroom is combined with teaching in a virtual learning environment (VLE). It is important to determine how a primary school teacher can use VLE communication and collaboration tools to teach mathematics primary school students.

Participants – 4th grade students ((n = 51). Access to quantitative studies has been chosen for the study. Methods of study: Analysis of scientific literature, testing, descriptive statistics, and inference statistics. Data from the pilot study and the educational experiment were processed using version 23 of the IBM SPSS Statistical Package for Social Sciences. The normality of the variable distribution was tested using the Shapiro-Wilk test. Throughout the research, decisions are taken at a value a = 0.05. Study adhered to the fundamental principles of the European Code of Conduct for Study Ethics. The curator of the education was in contact with the students and their parents by e-mail and using the VLE communication and collaboration tools (messages, forums, feedback). The aim was to find out whether the number of emails and messages sent by the curator affected the students' learning time in the VLE. The hypothesis of zero Pearson coefficient equality in the population is checked.

There was a statistically significant weak relationship between the number of emails sent by the curator of the curriculum, the number of messages for students and the time spent by the student for the lessons of the curriculum. There was a mean relationship in the boy's group, but there was no statistically significant relationship in girls' group.

There was also a statistically significant weak relationship between e-mails sent by the curriculum curator, the number of messages sent to students and the evaluation of the lessons of the curriculum. There was an average relationship in the boy's group, but in the girl's group there was no statistically significant relationship between the emails sent by the tutor, the number of messages to students and the evaluation of the lessons of the curriculum. This confirms the theory of constructivism that VLE is suitable for education because teachers can act as learning facilitators to communicate with each other during learning.

Keywords: mathematics, primary school students, virtual learning environments Moodle.

INTRODUCTION

The further, the more teaching(s) in a real-life classroom is combined with teaching and learning in a virtual learning environment (VLE). Research shows that the use of a VLE in education encourages students to take responsibility for their learning achievements, to learn collaboratively [1], and for the teacher to communicate with students' parents [2].

Looking at the use of VLE in teaching mathematics, it was found that virtual learning engages the student into the learning process, allows for collaboration with remote students [3]. Integration of virtual reality game elements by learning to apply fractional operations in real life, promotes better mathematical achievements of primary school students [4]. The use of problem-solving methodologies integrated with advanced computer environments, automated assessment, and web conferencing systems in a VLE promotes student interaction and helps teachers train students to design, speculate, explore, test, and verify [5]. In modern VLE, the use of integrated communication and collaboration allows to advise and evaluate the student's knowledge and abilities, to offer him the most suitable individual learning path [6], to develop responsibility and integrity by performing interactive tasks [7].

From the research carried out, we can see that attention was paid to the development of mathematic abilities of primary school pupils in the VLE. However, there is still a lack of a holistic approach to the use of VLE's Moodle

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communication and collaboration tools to develop the mathematic abilities of primary school students. In view of the situation discussed, the scientific problem of the research is formulated – how a primary school teacher can use the VLE Moodle communication and cooperation tools to promote the development of mathematics abilities of primary school students. The problem issue highlights the object of the study – the use of communication and collaboration tools in the VLE Moodle for learning mathematics in primary school. The aim of the research is to reveal the use of VLE Moodle communication and collaboration tools to develop the math skills of primary school students. Methods of research: analysis of scientific literature, testing, descriptive statistics, and inference statistics.

LITERATURE REVIEW

VLE is a learning management system with learning content, communication and evaluation tools, links to additional sources of information [6]. When learning in a virtual learning environment, the teacher helps the student using the tools of the virtual learning environment [8]: content management; preparing tasks and organizing surveys; student learning, tracking and evaluation of progress; administration-management tools; communication and collaboration tools. Communication and collaboration tools (conversations, videoconferences, messages, discussion boards, calendars, feedback) are designed to support remote communication between participants in the learning process [9].

Learning in Lithuania, as in the world, is used both commercially and open source VLE. However, the commercial VLE is paid and not accessible to all students and teachers. Therefore, as an alternative to commercial VLE, open-source environments are created and distributed free of charge, which can be customised to their own needs without prejudice to the license agreement. Open-source VLE Moodle developed by Australian scientists is widely used in Lithuania. In this environment, teachers can publish educational materials, present homework, develop knowledge and competence tests, communicate with students and their parents. VLE Moodle offers a student-centred toolkit and a friendly learning environment (see Table 1).

Table 1 VLE Moodle TOOLS

VLE Moodle Tools	**VLE Moodle Function**
Educational Content Management Tools	Ability to create educational content using internal content creation tools, insert content from external sources [9].
Tools for drafting tasks and organizing surveys	Ability to create tasks, tests, compile and submit surveys using a wide range of tools, activities, and resources.
Students' learning, progress monitoring and evaluation tools	Possibility to apply automated, manual evaluation, self-assessment, peer, individual or group assessment, including interactive content [9]
Communication and cooperation tools	Ability to communicate synchronously and asynchronously, to use co-creation activities.
Administration-Management Tools	Convenient user registration, user interface.

It is noted that students who communicate in a virtual environment often engage in tasks and problem solving, therefore virtual environments are increasingly included in math learning so that students can learn to solve problems [10]. By integrating elements of virtual reality game by learning to apply fractional operations in real life found better mathematical achievements for primary school students.

RESEARCH METHODOLOGY

To determine the experience of VLE tools using in math lessons, a group of subjects was formed using availability sampling, where the general sample units are included in the sample that are most accessible to the researcher. The sample size was determined using the Paniotto single-level randomisation formula. Participants of the research (n = 51) are 4th grade students.

The systematic analysis of literature helped to understand the benefits of applying the VLE in learning mathematics. However, an instrument suitable to determine the impact of the use of VLE communication and cooperation tools on the development of mathematical abilities of primary school students was not found. Therefore, first, a mathematical competence development program was developed and validated and placed in a virtual learning environment Moodle. In the selection of the tasks, the topics of educational content that were studied by class 4th grade students during the study were considered. The topic of content was analysed not only in the documents regulating the content of education in Lithuania but also in the International Mathematics and Sciences TIMSS program.

The study used open source VLE Moodle to support modelling and pedagogical interaction of educational learning content. This environment was chosen with the support of researchers [11] insights, researcher's experience to administer and organize education(s) VLE Moodle, free access to the VLE environment.

Before creating the lesson tasks, the tasks were piloted. The process of testing the tasks allowed to see typical mistakes made by students, to turn part of the tasks into a closed type to suit the lessons electronically in a virtual learning environment. Each task and its assessment instruction were tested in a group of 14 students, and by evaluating and considering the results obtained, modelling the compliance of the task with the level of student learning achievement, cooperated with 3 teachers and 2 scientists.

The lessons of the curriculum were prepared using the activity "Test" of the VLE Moodle. The author of the study gave all lessons to 4th grade students (25 boys and 26 girls) remotely. After each lesson, she provided feedback to students using communication and collaboration tools. Her parents and teachers helped her to organise the pupils' participation in the classes.

Research adhered to the fundamental principles of the European Code of Conduct for Research Ethics [12]: reliability, integrity, respect for colleagues, responsibility for research. Research Ethics Principles provide that students' participation in the study should be voluntary. Participants were informed that they could withdraw from the experiment whenever they wished and not to exert any pressure if this happened. However, regular contacts were maintained with the pupils, their parents and teachers who participated in the study to avoid spill overs. According to [13], the data collection procedure may raise concerns among study participants about its unusualness and novelty. In view of this threat, the investigator reassured the participants in the study before collecting the data, providing them with as much information as possible on the data collection procedure and dispelling concerns about data collection in a preventive manner.

The survey data was processed using version 27 of the IBM SPSS Statistical Package for Social Sciences.

RESEARCH RESULTS

We will discuss the results of the virtual learning environment Moodle communication and collaboration tools for learning mathematics. The general parameters of the activities carried out during the 4th grade education programme were analysed: number of emails, messages, student's time for educational program lessons, estimates of lessons of the curriculum.

The Shapiro-Wilks test was used to verify the normality of the distribution of those activities. It was found that the data for class 4th grade student' educational programme lessons scores, e-mails sent, number of messages, and time spent on the curriculum were distributed according to the normal law (see Table 2).

TABLE 2 RESULTS OF THE SHAPIR-WILK CRITERIA

Activities of the Education Programmer	**Shapiro-Wilks Criteria**		
	Statistics	**Number of degrees of freedom**	**Meaning of P**
Number of emails, messages	0,974	51	0,333
Time spent by the student for the educational program	0,961	51	0,089
Educational Program Lesson Task Estimates	0,962	51	0,100

For digital data, the Pearson criterion was used for the calculation of the correlation coefficient in the case of a normal distribution (see Table 3).

TABLE 3. RESULTS OF THE PEARSON CORRELATION COEFFICIENT

Activities of the Education Programmer		**Educational Program Lesson Task grade**	**Number of emails, messages**	**Time spent by the student for the educational program**
Time spent by the student for the educational program	Pearson's correlation coefficient	0,890**	0.401**	1,000
	Meaning of P	0,000	0,004	
Number of emails, messages	Pearson's correlation coefficient	0,475**	1,000	0.401**
	Meaning of P	0,000		0,004
Educational Program Lesson Task Estimates	Pearson's correlation coefficient	1,000	0,475**	0,890**
	Meaning of P		0,000	0,000

Curator of the curriculum, author of the study, contacted students and their parents by e-mail and using the communication and collaboration tools (messages, forums, feedback) in the virtual learning environment Moodle. As part of the lessons of the curriculum, students in primary classes had the opportunity to receive answers to their questions.

13 letters were sent to all students: the first – sending login data to the Moodle environment, the second – inviting you to participate in the educational program, third-eleventh inviting nine lessons of the educational program remotely, twelfth – inviting you to take a final test, thirteenth – sending gratitude to students for their participation. In addition, more emails and messages were sent to the students by repeatedly inviting them to take one or another test or to perform lesson tasks by answering students' questions. The number of emails and messages sent to students by the curator of the programme can be seen in "Fig. 1".

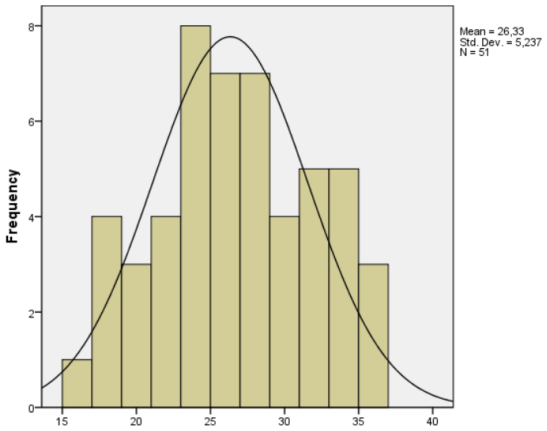

Fig. 1. Number of emails and messages sent to students by the curator of the education programme.

It was wanted to find out whether the number of emails sent by the curator of the education programme to the students had an impact on the time spent on the curriculum. The hypothesis of the population's Pearson coefficient equal to zero: Ho: $\rho = 0$; Ha: $\rho \neq 0$. The results of the linear correlation analysis are presented in Table 2.

The study showed a statistically significant ($p = 0.004$) weak ($r = 0.401$) relationship between emails sent to students by the curator of the curriculum, the number of messages and the time spent by the student for the lessons of the curriculum. In the boys group ($r = 0.599$), there was no statistically significant relationship in the girls group ($p= 0,180$). Thus, our study confirmed the idea expressed by other authors that educational activities organized by the VLE should be based on pedagogical interaction [14].

There was also a statistically significant ($p=0.000$) weak ($r = 0.475$) relationship between emails sent to students by the curator of the curriculum, the number of messages and estimates of school lessons. In the boys group ($r = 0.581$), there was no statistically significant relationship between e-mails sent by the curator of the education programme, the number of messages to pupils and estimates of school assignments in the girls group ($p = 0.015$). That learning in maths in a virtual learning environment can be more effective than conventional learning is also supported by other authors [15], arguing that similar learning outcomes are achieved in less time and effort.

CONCLUSIONS

After evaluating the impact of using the communication and collaboration tools of the VLE Moodle on the development of students' mathematical abilities, it can be concluded that the number of e-mails sent by the curator of the educational program had an impact on the student's time devoted to learning and the estimations of the tasks of the educational program lessons.

There was a statistically significant weak direct link between emails sent to students by the curator of the programme, the number of messages and the time spent by the student in the curriculum.

A strong direct statistically significant link was established between the time spent by the student for the lessons of the curriculum and the estimates of the lessons of the curriculum.

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Organization of Distance Learning in the Ukrainian Practice of Inclusive Education

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***Abstract*. This paper presents the issues of distance education, basic research on inclusive education and the current need for teacher training. The sudden «jump» from full-time distance learning has created a «collapse» in terms of inclusion. That is why our study considered: difficulties formation of inclusion and non-compliance and opportunities for all participants in the educational process; narrow orientation subjects and the lack of real practice for working with children with disabilities in the proposed training program for teachers; mismatch legal requirements and opportunities for schools to provide socialization and getting proper education of children with disabilities.**

During the collection and analysis of information, we used remote research methods, which included survey using Google forms; online meetings and interviews with teachers and teacher assistants; online discussions on the specifics of the proposed content and its adaptation to the needs of the inclusive class and for children with disabilities.

According to the results of our research, we found some contradictions between the requirements for the creation of an inclusive educational space, the forms offered for distance learning, and the opportunities of participants in the learning process. It is possible to design and develop specialized courses for teachers working with children with disabilities.

Keywords: children with disabilities, distance education, inclusive education, teacher training.

I. INTRODUCTION

It is worth noting that in contrast to Ukraine, global trends in the widespread use and implementation of distance education have been vividly discussed and tested since 1728 as «education by mail» [1] and since the 1960s as «e-learning» – learning through computers [2].

Thus, distance learning was in many cases seen as such, which was carried out with the help of postal communication or self-study with two sessions during the semester - one for receiving information and practice («lecture») and the other for examinations, which is practiced in Ukraine until now. But, we are more interested in a new type of distance education, which has become popular and is an effective substitute for the classroom-tutorial system of school education during the quarantine period - with the use of computer technology and the Internet.

According to our observations and taking into account the technological capabilities of Ukrainians and their computer competence in using information and communication technologies (ICT) and the Internet in Ukraine, the process of active involvement of educators in online education began in 2013-2014. At that time,

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institutions of higher education began to practice working in the Moodle database [3, 4, 5], although it is still less «popular». The next step towards the implementation of the new format of distance education was the dissemination of information about the Coursera online platform created in 2012 through mass media and social networks. It became available in Ukraine in 2013. Also, the online platform of massively open interactive courses «EdX», founded by the Massachusetts Institute of Technology and Harvard University, which has been available in Ukraine since 2014.

Moreover, during the same period, Ukrainian specialists implemented the Prometheus project, which is still working with Ukrainian content. Also, a Ukrainian platform «EdEra» was created in 2014, but its popularity grew only in 2018 when the Ministry of Education and Science 'launched' its programs to prepare for external independent evaluation of students and to raise the qualification of teachers in accordance with the primary school reform and the transition to the «New Ukrainian School». The «Modern Stage» of 2018, which gave rise to an active educational propaganda - the activity of the platforms «To the Lesson» and «Vseosvita», which gave the possibility of interaction between teachers and specialists, and with students.

Turning to the issues of inclusive education in Ukraine until 2019 and afterwards, the education sector was faced with the problem of updating the system of educational services and the transition to distance learning, just like in the rest of the world. This has led to a series of «disadvantages», which required a quick response. Among these, the most serious were (according to our observations):

- The transitional period in accordance with the established educational reforms and the existence of three parallel educational «innovations» in school practice;
- The lack of technical capacity on the part of both education providers (educational institutions, teachers and specialists) and the receiving side (pupils, students);
- The lack of ICT competence among some teachers and trainers, which made communication difficult and often reduced the teaching process to posting by e-mail;
- The low motivation of the recipients of educational services due to the lack of a «herd mentality», the perceived «technical advantage» over teachers and the lack of well-formed skills in self-awareness, critical thinking and information retrieval.

Thus, while the practice of distance education in the world had positive trends, the transition to this form of educational services in Ukraine was opposed by both: educators and parents of children and young people enrolled in education. Inclusion in general was also an important issue, as the quarantine period did not simply disrupt the social contacts of children with disabilities, but in some cases deprived them of the opportunity to receive any social, rehabilitation or correctional services. Therefore, the establishment of inclusive education during this period often gave priority to education and led to the 'neglect' of children's socialization.

Thus, the ***purpose*** of our research is to analyse the main provisions necessary for the quality implementation of distance and inclusive education, as well as the challenges in the sphere of their interaction. Since both forms of educational process organization are quite new and require search and presentation of modern inclusive practices in Ukraine, preparation for their implementation and integration into the process of distance education in practice, taking into account the needs of all participants in the educational process.

Therefore, while working on this topic, we identified the following tasks, some of which are presented in this review:

- to identify difficulties in the formation of an inclusive educational environment in Ukraine, which will allow further revision of controversial issues and provide better opportunities for children with special educational needs in the process of socialization, for which this form of interaction in the educational process is provided;
- to explore the availability of teacher training programmes that could provide the necessary knowledge in narrowly oriented subjects, as well as the skills to work in a distance learning format in an inclusive educational environment. This, in turn, was caused by a lack of real practice in working with children with special educational needs because of quarantine restrictions;
- to explore the needs and capacities of schools in providing inclusive education, in particular through the relationship between legal requirements, the provision of socialisation in school and the provision of appropriate education for children with special educational needs through distance inclusive education.

In particular, in this review, we present the results of the second strand of our research on teacher education programmes.

II. MATERIALS AND METHODS

From 2019 to 2020, we used data and literature review as well as data from the experiment to collect and analyse information. Thus, in the preparatory phase, we identified the main challenges of distance and inclusive education and the need to regulate their interaction, which was presented in the introductory section. Further, we came to the need to obtain data experimentally, which was realized in a distance format on the basis of the project of interaction with the participants of training in the Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, specialization «Inclusive Education». The solution of the tasks of this research was conditionally divided into three stages with the expansion of the audience:

- Thus, in the first stage we involved 64 students of the Valentina Voloshyna Faculty of Preschool and Primary Education. Part of the respondents, 42 were primary

school teachers and teaching assistants with an additional qualification in Inclusive Education and 22 were students studying or completing their first degree (7 were full-time students and the remaining 15 were part-time in-service students). So, all 64 respondents were enrolled in the courses «Teaching in an Inclusive Environment» and «Pedagogical Technologies of Inclusive Education» in 2019 and 2020, which allowed us to identify the needs for adapting the content of the educational process to the needs of the inclusive classroom and for children with special educational needs. In order to achieve the aim and objectives of this study, we used a discussion-style interview with the participants;

- In the second stage we used the same groups of students after 4 months of training to work with the questionnaire «Anketuvannia vchyteliv» (2020) [6], which gave us an opportunity to analyse teacher training issues presented in this article;
- The third phase involved interaction with the previously involved participants in the project (64 respondents, participation in the survey), participants in the Weber messenger group (7168 participants, participation in the survey) and participants in the focus group on «Inclusion in Education» (20 participants, participation in the survey).

In this article, we present some of the results of questionnaires and discussions that relate directly to the issues of preparing teachers to work in inclusive distance learning and the available online materials on this topic.

III. RESULTS AND DISCUSSION

To determine the level of awareness of educational staff about the organisation and implementation of inclusive education, we conducted a Google Forms survey on the main professional development offers on open platforms.

In total, there are three platforms that are most often used by primary school teachers in Ukraine («To the Lesson» [7], «Vseosvitaya» [8] and «EdEra» [9, 10, 11, 12]), though there are many more platforms available on the Internet as we mentioned earlier. So, choosing the ones that have been working at the Ukrainian educational sector for quite some time, we found that two of them have English content translated into Ukrainian and / or Russian language: «Prometeus» [13], «Coursera» [14] and one more «EDX» [15], which has only English content. It turned out that there are not so many professional development programs in the field of inclusive education (Table 1). Only 102 courses, of which 7.8% are in English and 3.9% have Russian-language content, which is not conducive to a wide use of this information due to the low language competence of the users (according to the respondents). And, just as importantly - only 5.9% of them are completely free of charge, while others have conditionally free access to the viewer with paid certification. Regardless of this, among the identified paid platforms, most practitioners often use the «To the Lesson» and the «Vseosvita» Web platforms.

Table 1: Online professional development platforms for teachers available in Ukraine

Platforms	Number of training courses for inclusive education, pcs.	Number of webinars for training for inclusive education, pcs.	Language	Cost of courses	Note
To the Lesson	0	42	UA	Paid / conditionally free of charge	
Vseosvita	23	19	UA	Paid / conditionally free of charge	
EdEra	4	0	UA	Free	Two courses only partly concern inclusive education
Prometeus	2	0	UA	Free	Two courses are only partly concerned with the organisation of inclusive education
Coursera	8	0	UK / RU	Paid / conditionally free of charge	Only four courses are translated in Russian
EDX	4	0	UK	Paid / conditionally free of charge	

At the same time, we added to the questionnaire the questions about taking courses on the EdEra platform, which were recommended by the Ministry of Education and Science of Ukraine. According to the recommendations and the need to form social acceptance of inclusive education by teachers, we selected the following courses for the survey: «Working of primary school teachers with children with special educational needs», «Online course for primary school teachers» (module 6), «Participation of parents in the organisation of inclusive education», «Non-discriminatory approach to learning» (Fig.1). The survey results showed that most of the practicing teachers (84%) followed the Ministry's guidelines by completing the Working of primary school teachers with children with special educational needs course, and 16% of them, including 3 practitioners and 7 students, are currently in the process of the course evaluation.

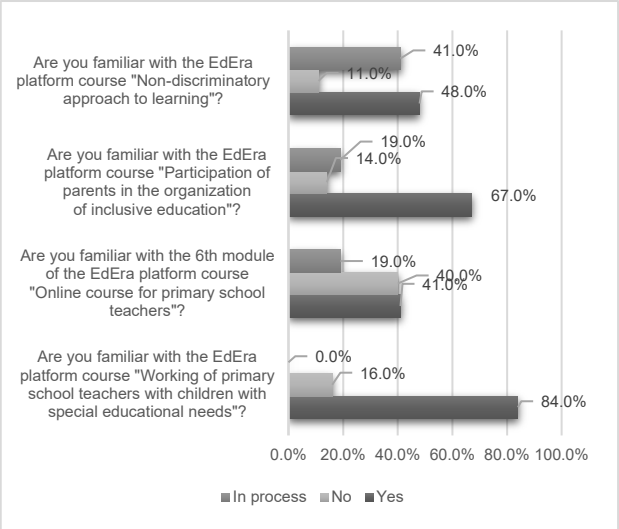

Fig. 1. Analysis of respondents' awareness of EdEra content.

We find it striking that another course recommended by the Ministry of Education and Science – «Online course for primary school teachers», where only the 6th module covers the subject of inclusive education, was evaluated by only 41% of the respondents. On the other hand, the course is recommended and necessary for teachers who are beginning to work in the New Ukrainian School system. That is why there is such a high percentage of those who are not aware of the course (40%).

We recommended the other two courses. So, the number of those who have read them varies greatly. However, while 86% of students did not encounter any problems with the Participation of parents in the organisation of inclusive education and its relation to the issues raised at our meetings - of whom 67% completed the course and 19% were still in the process. The course's Non-discriminatory approach to learning was widely debated. This was also reflected in the indicators: 48% were familiarized and taking into account the results of discussion during the online meeting, we received another 41% of those who began to get acquainted with the course.

Also, it should be noted that of the courses and webinars offered on all Ukrainian platforms, only a few webinars had a practical orientation and were related to the organisation of distance education. It is: «Electronic educational game resources are new opportunities for Inclusive Education», «Online services for the organisation of distance and blended learning for children with SEN», «How to organise effective speech therapy work in the conditions of distance learning», «Features of distance learning of children with special educational needs».

This leads us to believe that the problems we identified in the first stage of our research affect the formulation of educational content and the restructuring of the educational process. In particular, the reform of the education system and the lack of clear guidelines for distance learning in inclusive classes.

We thought it was important to determine the motivation of the teachers' assistants to receive information about the organisation and implementation of inclusive classroom activities. So, we asked our respondents (64 persons) to fill in a questionnaire on the needs of practitioners and theorists in inclusive education. We also asked this questionnaire to be filled in by professionals who are members of the Ukrainian group «Teacher's Assistant Ukraine» (7168 persons) via Viber messenger. The questionnaire could help to identify the main issues that need to be presented adequately to the general public and on the basis of which appropriate courses to improve the qualifications of teachers should be developed. The questionnaire was anonymous and contained only nine items. However, from the time of publication of the proposal for completion we received only five responses, which in itself showed the «low» efficiency of surveying the audience through groups in various messengers.

It also showed the low motivation of our respondents we met during the training course. A month after the questionnaire was published, we were able to ask our respondents about the completion of the questionnaire and the information it contained during the online session. Among the responses we can mention the following.

"I did not have time to answer, but we looked at all the questions in class" (respondent 15).

"It was not for evaluation, so I decided to give priority to other tasks" (respondent 22).

"Everything I am interested in, I find on the Internet or ask my colleagues" (respondent 35).

Thus, we were able to evaluate both the method of information transmission and the motivational decisions of the main part of the respondents. It should also be noted that thanks to the responses of our colleagues to this questionnaire, we were able to get acquainted with the request for information from specialized specialists - a speech therapist, two defectologists, educators and a social worker. It should be noted that the questions corresponded to the scope of each specialist's work. While the speech therapist and defectologist were interested in the development and quality management of the individual development programme and other support documentation, the educator and social worker were interested in the following issues:

"Developmental tasks for children with special educational needs" (respondent educator),

"Written timetable, as a basis for activities, manuals for nosology" (social worker respondent).

Currently, all of the courses and webinars offered on online platforms provide theoretical aspects about the law and the characteristics of children with special needs. At the same time, it is very difficult to find materials or practices for applications of record keeping and working methods, which can be easily implemented in a typical primary school lesson or a visual explanation of how to use a particular technique, device or adapted materials. The problem in this case is also due to the fact that each local education department and methodology office create and approve «their» materials on the basis of the legislation, which once again confirms the inadequate implementation

of reforms at the local level. This in turn complicates the process of mutual adaptation of a child with special educational needs to the school and, consequently, the school and the participants in the educational process to the child.

IV. DISCUSSION

At the same time, if we turn to the issue of problems that arose in the process of transition to distance education, which we voiced in the introductory part, we can note that the issue of low motivation can be «fought» during training by re-crediting online courses as independent work of students, or by holding open debates on issues covered in the proposed courses, in particular on their practical application in offline learning, distance education or mixed form, or on the application of examples and theory to work with children with SEN and organisation of

At the same time, other positions are questionable and can be attributed to the debatable issues of further development of the education sector in Ukraine due to the closeness of the educational system to external observation, the lack of quality content created by teachers themselves and presenting work directly with children, experience in implementing inclusive education in a regular classroom or a classroom working under the NUS programme.

For us, this component of organising distance education and training for future specialists through familiarisation with practical advice and visualisation of «pedagogical situations» rather than theoretical courses is an important part of supervision and experience exchange. However, whether due to the «personal data law» or the low level of proficiency in the technologies currently available for creating video messages and stories, including the ability to promote them on the Internet (insufficient CEO potential and description of the presented experience in video format), the lack of video recording skills and high-quality content design creates a «pedagogical vacuum» for improving the practice of both teacher training and improving methods, forms, techniques through the exchange of experience in an open format, which we can observe in the English-speaking world.

In addition, when we had the opportunity to conduct a preliminary survey of teachers on the issue of video interviews for educational purposes, only three of the 46 teachers surveyed agreed to participate, one of whom agreed to a video interview and the other two to a voice recording.

This raises even more questions about the organisation of the educational process, which, in our opinion, are not only worthy of attention, but should be addressed from the perspective of the teacher, school, and management; the formation of a remote educational space and the inclusion of each child in the educational process; parents who choose the format and «mentor» of the educational process for their child; and, most importantly, from the perspective of the child with or without special educational needs. And although this part of the «reflections» and the results of observations and «communication» may lead to an even greater discussion, we have to return to the part that was «central» to this research.

V. CONCLUSIONS

Thus, we analyzed weaknesses in the training and professional development of teachers and teaching assistants to work in inclusive education space and developed additional specialized courses for teachers; developed a list of online platforms and professional development courses for self-study by motivated teachers and teaching assistants.

We believe that all these should contribute to the success of innovative approaches to working with children with special educational needs in inclusive practice, their peers in both inclusive classroom and distance education settings, regardless of the challenges and dynamics of today's world.

All this does not exclude the need to consider for further work such issues as the psychological and pedagogical characteristics of children according to their nosology offered by inclusive resource centres; how to maintain school records, their open and closed information to improve the quality of psychological and pedagogical support for all children (including normotypical) in the distance inclusive education; practical forms and methods of work with children of this or other categories in classroom-based system, NUS and distance learning.

It is worth noting that against the background of the existing challenges, we continue to consider the issues outlined at the beginning of this article and to study the results of the implementation of updated programs and various forms of practice-oriented information, which will be presented in our next studies.

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Global Competence Development Among Computer Engineering and Information Technology Undergraduates in the English Language Classroom

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***Abstract*. Nowadays higher education institutions are directly involved in the training of new personnel, so they should seriously puzzle one of the most obvious questions today, how to prepare students to meet the challenges of Industrial Revolution 4.0 in an increasingly globalised society. And although the unequivocal answer to this question doesn't exist, one thing is certain: while providing Education 4.0 through incorporating advanced technology into the curriculum for implementing best practices and innovative methodological approaches, methods and techniques, higher education institutions should do their best to shape the next generation of highly employable global citizens who can think and act from a global perspective. In the future students who specialise in the field of Computer Engineering and Information Technology will be at the forefront of advancing the technology available to all people in the world and, therefore, they should be globally competent. It means that they should possess a global competence to successfully compete on a global scale. Significant practical experience gained by the authors of the article made it possible to assume that being one of the humanities which is taught to Computer Engineering and Information Technology undergraduates in Ukrainian higher education institutions, English has a great potential for developing their global competence. Considering the fact that Ukrainian 15-year-old students were not a part of the PISA 2018 Global Competence assessment, the present research was aimed at finding out how the participants understood the concept of "global competence", their awareness of the importance of global competence development in accordance with the requirements and principles of Education 4.0 associated with the Industrial Revolution 4.0 and participants' views on the role of the English language in its development. For exactly this purpose the authors made a questionnaire in Google Forms. The research participants were 249 Computer Engineering and Information Technology undergraduates who were selected by means of a purposeful sampling method. The conducted research shows that the didactic uniqueness of the English language as an academic discipline aimed at developing global competence is manifested in the fact that it can be seen as both a learning goal and a learning tool. The results obtained became the basis for devising a paradigm defining strategy (the core strategy) and four sub-strategies effective for developing Computer Engineering and Information Technology undergraduates' global competence in the English language classroom.**

Keywords: Computer Engineering and Information Technology undergraduates, Education 4.0, English as a medium of instruction, global competence, global skills.

I. INTRODUCTION

Nowadays higher education institutions are directly involved in the training of new personnel, so they should seriously puzzle one of the most obvious questions today, how to prepare students to meet the challenges of Industrial Revolution 4.0 in an increasingly globalised society. And although the unequivocal answer to this question doesn't exist, one thing is certain: while providing Education 4.0 through incorporating advanced technology into the curriculum for implementing best practices and innovative methodological approaches, methods and techniques, higher education institutions should do their best to shape the next generation of highly

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employable global citizens who can think and act from a global perspective [1] – [4]. In the future students who specialise in the field of Computer Engineering and Information Technology will be at the forefront of advancing the technology available to all people in the world and, therefore, they should be globally competent. It means that they should possess a global competence to successfully compete on a global scale. Significant practical experience gained by the authors of the article made it possible to assume that being one of the humanities which is taught to Computer Engineering and Information Technology undergraduates in Ukrainian higher education institutions, English has a great potential for developing their global competence. Considering the fact that Ukrainian 15-year-old students were not a part of the PISA 2018 Global Competence assessment, the present research was aimed at finding out how the participants understood the concept of "global competence", their awareness of the importance of global competence development in accordance with the requirements and principles of Education 4.0 associated with the Industrial Revolution 4.0 and participants' views on the role of the English language in its development.

II. Literature Review

Life in a globalised society provides young people with growth opportunities, on the one hand, but, on the other hand, it requires from them gaining new knowledge, skills and attitudes which can ensure their conscious and critical understanding of changes taking place in the world, active participation in the life of local and international communities, demonstrating behaviour typical of responsible global citizens [5]. Additionally, these new skills, knowledge and attitudes are thought to promote their successful employment on the global labour market. It means that to be able to compete globally and to succeed as an accomplished individual and a true professional, young people have to be equipped with skills essential for the work and life in the 21st century [6] – [9] including the global competence regarded as one of them [10]. And although the concept of "global competence" has been in a scientific circulation since the last century, the present-day pedagogical literature lacks a common, generally accepted definition. On the contrary, it has already accumulated various approaches to defining the concept of "global competence" and to identifying knowledge, skills and attitudes which constitute this concept.

In the document entitled "PISA 2018 Framework Plans" which became a first draft of the framework for assessing global competence as the additional domain of PISA 2018, global competence was defined as "the capacity of an individual to understand that we learn, work and live in an international, interconnected and interdependent society and the capability to use that knowledge to inform one's dispositions, behaviours and actions when navigating, interacting, communicating and participating in a variety of roles and international contexts as a reflective individual" [11, p. 9]. The drafters of the proposed document also identified a combination of knowledge, skills, attitudes and behaviours which comprised global competence and categories within which students should be able to apply this combination of knowledge, skills, attitudes and behaviours. These categories included language/communication, culture/identities, principles/values and systems/institutions/events/trends [11].

Comparing the concept of "global competence" with other concepts considered to be identical (for instance, global citizenship, intercultural communication, etc.), the next document "PISA 2018 Draft Global Competence Framework" reveals its essence in more detail [12]. According to it, the main thing which distinguishes global competence from related concepts is that "it combines interacting effectively and appropriately with people from other cultures with a knowledge and understanding of the interconnectedness of local and global issues, including the power of new communications and information technologies and the disposition to engage responsibly and effectively in a global environment, particularly in work-based settings" [12, p. 4-5]. The document also identifies four dimensions where a globally competent person can apply required knowledge, skills and attitudes in the contexts of learning, working and living, namely: "… (1) knowledge and interest in global developments, challenges and trends; (2) openness and flexibility; (3) emotional strength and resilience; and (4) communication and relationship management" [12, p. 14].

Document "Educating for Global Competence: Preparing Our Youth to Engage the World" defines global competence as "the capacity and disposition to understand and act on issues of global significance" [13, p. xiii]. It should be mentioned, that one of the main ideas raised in this document is that "to be competitive, ethical, and effective workers, today's students must understand key topics of global significance in areas like engineering, business, science, history, ecology, and other domains that may constitute their future work" [13, p. 2]. Therefore, the main four sub-competences which constitute the global competence can be manifested in students' ability (1) to investigate the world beyond their immediate environment, (2) to recognize perspectives, others' and their own, (3) to communicate ideas effectively with diverse audiences, (4) to take action to improve conditions [13, p. 11].

In the document entitled "*Teaching for Global Competence in a Rapidly Changing World"* developed by Asia Society together with OECD, it is possible to find a more detailed definition of the concept of "global competence": "Global competence is the capacity to examine local, global, and intercultural issues; to understand and appreciate the perspectives and world views of others; to engage in open, appropriate, and effective interactions with people from different cultures; and to act for collective well-being and sustainable development" [14, p. 5]. The document also identifies four aspects of global competence that are reflected in its definition. These four aspects of global competence are as follows: (1) "the capacity to critically examine issues such as poverty, trade, migration, inequality, environmental justice, conflict, cultural differences, and stereotypes" [14,

p. 5]; (2) "… the capacity to understand and appreciate different perspectives and world views" [14, p. 5]; (3) "… the ability to interact positively with people of different national, social, ethnic, and religious backgrounds, as well as those of different genders" [14, p. 5]; "… being willing to act constructively to address issues of sustainability and well-being" [14, p. 5].

Literature analysis clearly demonstrates that in the realities of the 21st century the development of soft skills including global competence promises to be a crucial supplement to engineering education in general [9], [15] – [17] and computer engineering education in particular [6] – [8]. The basis of their assertions is rooted in the belief that it is the global competence that connects "important knowledge, skills, and attitudes relating to intercultural communication and collaboration to a sustainability mindset" [15, p. 3]. Positing that global competence "is a continuum with no endpoint, rather than a have or have not quality" [15, p. 3], Kjellgren and Richter [15] claim that it combines two spheres, namely, a personal sphere and an interaction sphere. The scholars believe that whereas a personal sphere includes "the individual's own knowledge, skills, and attitudes" [15, p. 3], an interaction sphere is manifested in "the individual's behaviour in communication, collaboration, and relation-building" [15, p. 3].

In our research we can expand on Parkinson' idea and state that after graduating globally competent students who specialise in field of Computer Engineering and Information Technology will be able to become active agents of change capable of changing their own lives and the world for better through managing and directing their activities at a local, national and global levels [16]. Parkinson's rationale for developing global competence is based on the ideas described in the paper "Developing Global Competence in Engineers: What does it mean? What is most important?" written by him and his colleagues [17]. The rationale identifies following 13 dimensions of global competence specific to engineering profession: ability to appreciate other cultures, ability to communicate across cultures, knowledge on the history, government and economic systems of several target countries, ability to speak a second language at a conversational level, ability to speak a second language at a professional (i.e. technical) level, ability to work in or direct a team of ethnic and cultural diversity, ability to effectively deal with ethical issues arising from cultural or national differences, ability to understand cultural differences relating to product design, manufacture and use, ability to understand the connectedness of the world and the workings of the global economy, ability to understand implications of cultural differences on how engineering tasks might be approached, exposure to international aspects of topics such as supply chain management, intellectual property, liability and risk, and business practices, possibility to practice engineering in a global context, whether through an international internship, a service learning opportunity, a virtual global engineering project or some other form of experience; viewing themselves as "citizens of the world," as well as citizens of a particular country [16].

Research analysed above enables us to identify the following attributes of global competence which we include in the online questionnaire and which are of interest to us, namely: (1) ability to appreciate other cultures; (2) ability to communicate across cultures; (3) knowledge on history, political and economic systems of different countries; (4) ability to understand multiple spheres of participation in local, national, and global communities; (5) ability to participate actively in local, national, and global communities; (6) ability to speak a foreign language; (7) ability of understand cultural differences relating to product design, manufacture and use; (8) ability to manage own work for ongoing improvement and adapting to change; (9) ability to work in a team of ethnic or cultural diversity; (10) ability to deal with ethical issues arising from cultural or national differences; (11) ability to understand current and future climate solutions.

III. Materials and Methods

The researchers designed an online questionnaire using Google Forms. The online questionnaire included open-ended and close-ended questions. Moreover, respondents were offered to score the importance of global competence components on a 4-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree).

The research sample consisted of 249 Computer Engineering and Information Technology undergraduates who were selected by means of a purposeful sampling method. The researchers were interested in undergraduate students whose specialty was either Computer Engineering or Information Technology and who studied English at university. The researchers asked their colleagues who taught English to Computer Engineering and Information Technology undergraduates to share the link to the online questionnaire with them. Although, the researchers received a total of 264 responses back, but before analysing the results, they excluded 15 incomplete questionnaires from the data set.

These 249 research participants with complete questionnaires were representatives of three Ukrainian universities, namely, Kyiv National University of Technologies and Design (39.8%), Interregional Academy of Personnel Management (26.9%), Kryvyi Rih National University (33.3%). According to gender differences, male students represented 86.7% of the sample and female students represented of 13.3% the sample.

The online survey which lasted for 2 months during the 2022 autumn semester was anonymous.

The gender differences of online survey participants are given in Table 1.

TABLE 1 GENDER DIFFERENCES OF ONLINE SURVEY PARTICIPANTS

Higher Education Institution	Number of Participants			
	Male		Female	
	Number	Percent	Number	Percent
Kyiv National University of Technologies and Design	85	34.1	14	5.6
Interregional Academy of Personnel Management	74	29.7	9	3.6
Kryvyi Rih National University	57	22.9	10	4.1
Total	216	86.7	33	13.3

Source: own study (N=249)

Figure 1 illustrates the gender differences between research participants.

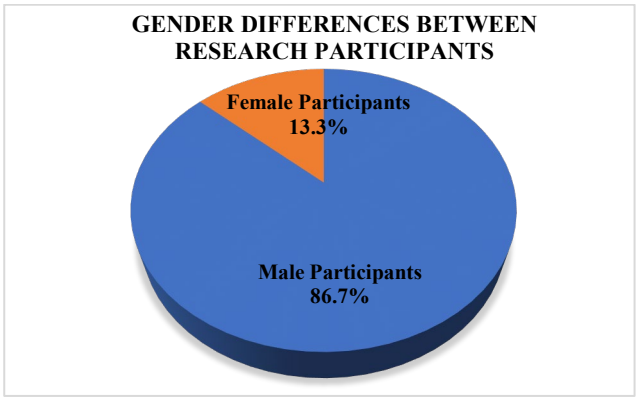

Fig. 1. Gender differences between research participants.

IV. FINDINGS AND DISCUSSION

The first question was focused on finding out if respondents had heard of the concept of "global competence" at all. Answering it, 82 respondents (32.9%) stated that they had not heard of the concept of "global competence" at all. 117 respondents (47.0%) replied that they had heard of it before and 50 respondents (20.1%) found it difficult to answer this question. Figure 2 presents the results concerning the first question.

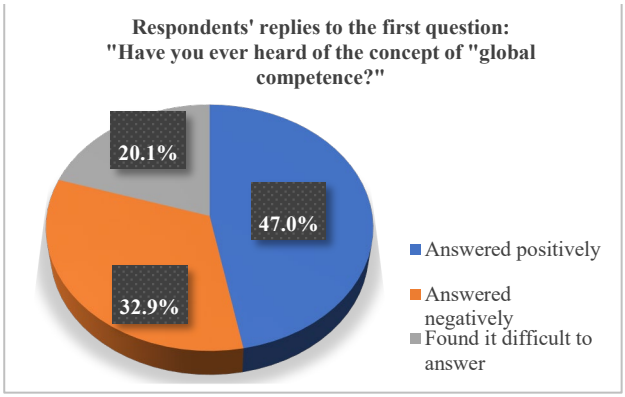

Fig. 2. Respondents'replies to the first question.

Then the respondents were asked to define the concept of "global competence". The respondents defined it as: (1) a person' ability to establish effective communication with people from different cultures and countries including foreign language skills (37.8%); (2) a person's ability to understand international and cultural differences (34.9%); (3) a person's ability to understand international relations between different countries in a present-day globalised world (18.9%); (4) a person's ability to understand the true reasons of social, political, economic and climate changes that occur all over the world and their consequences (8.4%).

Defining global competence as a person' ability to establish effective communication with people from different cultures and countries including foreign language skills, 94 respondents (37.8%) reply that they believe that their profession provides a bevy of job opportunities in various international companies in Ukraine or abroad and to succeed they should have knowledge about different countries, their traditions and cultures etc. They also point out that to communicate effectively with their colleagues who can be from other countries, foreign language skills are of particular importance. 87 respondents (34.9%) who define the global competence as a person's ability to understand international and cultural differences, are convinced that people who live in the present-day globalised world should love, appreciate and popularise the culture of their nation, but, at the same time, they should understand and appreciate the culture and traditions of other nations. 47 respondents (18.9%) consider that to be globally competent people should understand international relations between different countries. Answering this question, 21 respondents (8.4%) indicate that people have to understand the true reasons of social, political and economic changes that occur all over the world and their consequences. These respondents explain that despite the fact that life in a present-day globalised world is unpredictable people should have knowledge and skills which can help them take better decisions in planning their lives.

The researchers also intended to clarify to what degree respondents agreed that the proposed global competence components were of importance to them. The results obtained are presented in Table 2.

TABLE 2 RESPONDENTS' VIEWS ON IMPORTANCE OF GLOBAL COMPETENCE COMPONENTS

Variables	Strongly Disagree (N)	Disagree (N)	Agree (N)	Strongly agree (N)
Ability to Appreciate Other Cultures	0	5	76	168
Ability to Communicate Across Cultures	4	15	82	148
Knowledge on History, Political and Economic Systems of Different Countries	4	9	111	125
Ability to Understand Multiple Spheres of Participation in	4	12	127	106

Local, National, and Global Communities				
Ability to Participate Actively in Local, National, and Global Communities	3	14	121	111
Ability to Speak a Foreign Language	0	10	111	128
Ability of Understand Cultural Differences Relating to Product Design, Manufacture and Use	0	24	125	100
Ability to Manage Own Work for Ongoing Improvement and Adapting to Change	0	99	126	35
Ability to Work in a Team of Ethnic or Cultural Diversity	0	23	89	137
Ability to Deal with Ethical Issues Arising from Cultural or National Differences	0	14	101	134
Ability to Understand Current and Future Climate Solutions	11	25	112	101

Source: own study (N=249)

The next question was aimed at finding out whether respondents agreed that the English language could help them remain cognizant in various situations that occur in different countries for better adapting in the present-day globalised world. The results show that out of 249 respondents, only 3 (1.2%) responded negatively. 246 respondents (98.8%) gave a positive answer to this question. Respondents were also asked to give reasons for their answers. Below are some excerpts which provide an overall idea of students' views on the importance of the English language:

S1: English is a tool that helps to understand people, emotions they experience and values they hold regardless of their nationality and citizenship. … But I do believe that nowadays you should not focus on one language, because the more languages you know, the easier and quicker you will be to understand what moral and humanistic values people from different countries have as life priorities.

S19: I have many friends who live in different countries and English helps me find common language with all of them. We often discuss what happens in the world, share some useful ideas and information, tell each other about the novelties in the world of technologies…

S137: … Nowadays there are many online educational resources in English which can be used for gaining new knowledge and skills. The better you know English the more opportunities you have for your personal and professional development. Moreover, English helps me discover what is going on in the world from original sources and keep abreast of all the important events …

S203: *Undoubtedly, I agree with the fact that knowledge of the English language will help a person to adapt better in today`s globalised world. English language proficiency provides more opportunities for self-development, broadening one's horizons and developing critical thinking. And above all, it certainly helps in communicating with representatives of other cultures.*

The strategies for global competence development in the English language classroom were formulated considering the results obtained and the strategies targeted at enhancing soft skills among Computer Engineering and Information Technology undergraduates introduced in the process of learning English: "… a) combination of competence-based, action-oriented and blended-learning approaches in the English for Specific Purposes classroom, b) integration of formal, non-formal and informal learning, c) participation in specially focused network professional communities, d) use of open educational resources for learning English, e) use of open professionally-oriented educational resources, f) introduction of learning-style based activities in the English for Specific Purposes classroom for boosting students' soft skills" [8, p. 239].

The English language is one of the humanities which is taught to Computer Engineering and Information Technology undergraduates in Ukrainian higher education institutions. Computer Engineering and Information Technology undergraduates can learn such academic disciplines as "English as a Second Language" and "English for Specific Purposes" or both of them. It usually depends on curriculum approved by the rector of higher education institution. Thus, for instance, "English as a Second Language" can be taught during the first and second years of training and "English for Specific Purposes" can be taught during the third and fourth years of training. The results obtained enable us to conclude that the English language as an academic discipline has a much deeper potential for developing Computer Engineering and Information Technology undergraduates' global competence than other academic disciplines. In developing various 21st century skills (job skills of tomorrow, soft skills, social-emotional skills, communicative skills) including global competence the didactic uniqueness of the English language as an academic discipline is manifested in the fact that it can be seen as both a learning goal and a learning tool. Its main and ultimate learning goal is to develop Computer Engineering and Information Technology undergraduates' English language skills (reading skills, listening skills, writing skills and speaking skills). Simultaneous mastering of four English language skills contributes greatly to the development of Computer Engineering and Information Technology undergraduates' global competence and can become an effective learning tool for their developing. The following strategies can be applied in the English language classroom:

Strategy 1 – *Developing Computer Engineering and Information Technology undergraduates' global competence through modifying the content of such academic disciplines as "English as a Second Language" and "English for Specific Purposes".*

Drawing up the syllabus for "English as a Second Language" or the syllabus for "English for Specific Purposes", the emphasis should be placed on both the content of these academic disciplines used for absorbing information in general and information that is closely connected with the components of global competence in particular and methods and techniques aimed at mastering English language skills (reading skills, listening skills,

writing skills and speaking skills). We acknowledge this strategy as paradigm defining and do believe that its implementation will be effective under conditions of simultaneous implementation of four sub-strategies defined in accordance with four types of speech activity. It means that the content of mentioned academic disciplines should contain up-to-date information on events that occur in the world and consequences of these events, social-cultural diversity that exists in the world. The acquisition of such updated content should be realised through methods and techniques used in the English language classroom and targeted at promoting student's ability to identify a causal link between various events that happen worldwide and changes in the lives of people; cultural differences in communication; positive and negative effects of globalisation on social, political and economic spheres of life at local, national and global levels etc. While processing, interpreting, reproducing and retranslating updated information absorbed as a result of upgrading the content of either "English as a Second Language" or "English for Specific Purposes" or both of them, particular attention should be paid for enhancing the variety of 21st century skills (i.e., job skills of tomorrow, transformative skills, soft skills etc.). Involving Computer Engineering and Information Technology undergraduates into different types of speech activity which implies processing, interpreting, reproducing and retranslating updated information directly or indirectly connected with life in the present-day globalised world has unlimited didactic potential for both forming and developing Computer Engineering and Information Technology undergraduates' global competence (which is the subject of our research) and 21st century skills (i.e., job skills of tomorrow, transformative skills, soft skills etc.). According to various reputable sources [18] – [20], their forming and developing is of increasing importance for succeeding in personal life and professional development in the present-day globalised world.

The following sub-strategies are supposed to be effective in developing Computer Engineering and Information Technology undergraduates' global competence:

Sub-strategy 1 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English reading skills*.

Sub-strategy 2 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English listening skills*.

Sub-strategy 3 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English writing skills*.

Sub-strategy 4 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English speaking skills*.

V. Recommendations and Conclusions

So, to sum up, we can state that the English language as an academic discipline has an unlimited didactic potential for developing Computer Engineering and Information Technology undergraduates' global competence. The didactic uniqueness of the English language as an academic discipline aimed at developing various 21st century skills (job skills of tomorrow, soft skills, social-emotional skills, communicative skills) including global competence is manifested in the fact that it can be seen as both a learning goal and a learning tool.

The results obtained became the basis for devising a paradigm defining strategy (the core strategy) and four sub-strategies effective for developing Computer Engineering and Information Technology undergraduates' global competence in the English language classroom:

The core strategy acknowledged as a paradigm defining is *Developing Computer Engineering and Information Technology undergraduates' global competence through modifying the content of such academic disciplines as "English as a Second Language" and "English for Specific Purposes"*. We consider that implementation of the core strategy will be effective under conditions of simultaneous implementation of four sub-strategies defined in accordance with four types of speech activity, namely:

Sub-strategy 1 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English reading skills.*

Sub-strategy 2 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English listening skills.*

Sub-strategy 3 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English writing skills.*

Sub-strategy 4 – *Developing Computer Engineering and Information Technology undergraduates' global competence through mastering English-speaking skills.*

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Didactic Potential of Humanities in Developing Transformative Competencies among Computer Engineering and Information Technology Undergraduates

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Abstract. **In the recent decades harnessing the advanced information technologies and their tremendous potential to improve the quality of life for people all over the world is becoming an urgent need than a luxury. Knowing full well that as an innovative student-centred learning paradigm Education 4.0 creates favourable prerequisites for developing valuable professional skills, abilities and knowledge among Computer Engineering and Information Technology undergraduates, the researchers assumed that it also might be effective in preparing them for challenges of the contemporary world through developing their transformative competencies while studying the humanities. The paper aims to reveal the didactic potential of humanities for developing Computer Engineering and Information Technology undergraduates' transformative competencies. The researchers carried out an exploratory study in five Ukrainian universities using an online survey conceived and developed by a team of researchers. A total of 275 respondents selected by means of a purposeful sampling method took part in the survey. The study found that humanities (1) are more likely to apply various learning activities which can be done both individually and in groups than technical disciplines and (2) have much broader potential for developing all key constructs of transformative competencies among Computer Engineering and Information Technology undergraduates than technical disciplines. The results enabled the researchers to formulate recommendations for university teachers of humanities on how to develop transformative competences among Computer Engineering and Information Technology undergraduates. The combination of challenge-based learning (CBL) and activity-based learning (ABL) is being considered as a major methodological approach of Education 4.0 for developing transformative competences among Computer Engineering and Information Technology undergraduates. Scientific novelty of research consists in revealing and describing the didactic potential of humanities for developing Computer Engineering and Information Technology undergraduates' transformative competencies.**

Keywords: activity-based learning, challenge-based learning, Computer Engineering and Information Technology undergraduates, Education 4.0, transformative competencies.

I. INTRODUCTION

In the recent decades harnessing the advanced information technologies and their tremendous potential to improve the quality of life for people all over the world is becoming an urgent need than a luxury. Knowing full well that as an innovative student-centred learning paradigm Education 4.0 creates favourable prerequisites for developing valuable professional skills, abilities and knowledge among students [1] – [2], the authors of this paper assumed that it also might be effective in preparing Computer Engineering and Information Technology undergraduates for challenges of the contemporary world through developing their transformative competencies while studying the humanities.

More and more often researchers who are actively engaged in the problem of improving the training of Computer Engineering and Information Technology

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undergraduates emphasize that although the majority of present-day degree programmes for Bachelor of Science in Engineering in general and Bachelor of Science in Computer Engineering and Information Technology in particular are aimed at developing technical or so-called hard skills, higher educational institutions should also give due consideration to developing soft skills or competencies which will enable students studying at such programmes to make sound decisions and take responsible actions for the betterment of themselves and globalised knowledge-based society [3] – [8]. One possible explanation for it could be the fact that in the information era special requirements and high expectations are laid on students who specialise in Computer Engineering and Information Technology, since after graduating it is they who will be able to offer innovative technical solutions to upgrade aging information technologies, let alone to create breakthroughs in the field of computer science for further informatisation and computerisation of the world society. Taking the ideas set forth in the document entitled "OECD Future of Education and Skills 2030 Concept Note: Transformative Competencies for 2030" [9] as axiomatic, it should be noted that in order to achieve this objective, Computer Engineering and Information Technology undergraduates have to be equipped with three transformative competencies which can help them "shape the future for better lives" [9, p. 4].

Implying more than just the acquisition of knowledge and skills, the concept of "competency" includes the combination of such knowledge, skills, attitudes and values that enables their bearers to meet complex demands [10]. In this regard transformative competencies are those that "enable students to develop and reflect on their own perspective, and because they are necessary for learning how to shape and contribute to a changing world" [11, p. 8].

It should be noted that several concept notes developed by OECD identify three transformative competencies that "together address the growing need for young people to be innovative, responsible and aware" [10, p. 5]. These three transformative competencies are creating new value, reconciling conflicts and dilemmas and taking responsibility [9] – [11]. Each of the abovementioned transformative competencies consists of definite key constructs. Thus, for instance, sense of purpose, curiosity, open mindset, critical thinking, creativity, collaboration, agility, an ability to manage risks and adaptability are considered as key constructs of creating new value [9] – [11]. Key constructs which characterise reconciling conflicts and dilemmas as a transformative competency are cognitive flexibility, perspective-taking skills, empathy, respect towards others, creativity, problem-solving skills, conflict resolution skills, resilience, tolerance for complexity and ambiguity, sense of responsibility towards others [9] – [11]. Taking responsibility as a transformative competency is distinguished by locus of control, a sense of integrity, compassion, respect for others, critical thinking, self-awareness, self-regulation, reflective thinking, ability to build trust [9] – [11].

A search of the literature shows that being uniquely human transformative competencies can be effectively taught and learned during interactions with other people and, therefore, educational institutions on different levels can become an excellent place for their forming and developing. Moreover, one of the indisputable advantages of transformative competencies is that once learnt they can be used throughout the lifespan [9] – [11].

The present research is aimed at revealing the didactic potential of humanities for developing Computer Engineering and Information Technology Undergraduates' transformative competencies.

II. Materials and Methods

The researchers carried out an exploratory study in five Ukrainian universities using an online survey conceived and developed by a team of researchers. These universities were Kyiv National University of Technologies and Design (Kyiv, Ukraine), Interregional Academy of Personnel Management (Kyiv, Ukraine), National Aviation University (Kyiv, Ukraine), Kyiv National Economic University named after Vadym Hetman (Kyiv, Ukraine) and Kryvyi Rih National University (Kryvyi Rih, Ukraine).

To gather the information the researchers needed, they developed a web-based questionnaire in Google Forms. The essence of the concept of "transformative competencies", the approach to classifying transformative competencies and their key constructs provided by "OECD Future of Education and Skills 2030 Concept Note: Transformative Competencies" [9] formed the basis for developing a web-based questionnaire which consisted of three separate parts.

Considering the idea raised at the World Economic Forum in 2017 that by 2030 the role of women graduating with a degree in STEM field would be of vital importance to leveraging the Fourth Industrial revolution to benefit our global society [12], the first part of the questionnaire included one question concerning participants' gender and one question concerning the participants' place of study.

The second part of the web-based questionnaire was aimed at finding out how knowledgeable present-day Ukrainian Computer Engineering and Information Technology undergraduates were about transformative competencies and their key constructs, on the one hand, and assessing the importance of transformative competencies and their key constructs for participants' further professional development and succeeding in the future workplace, on the other hand. In this part of the web-based questionnaire respondents were asked to indicate if they were knowledgeable about the concept of "transformative competencies" and if they knew that creating new value, reconciling conflicts and dilemmas and taking responsibility constitute three transformative competencies. Then the respondents were asked to assess the importance of three transformative competencies (namely, creating new value, reconciling conflicts and dilemmas, taking responsibility) for achieving success and further professional development according to a 4-Likert

scale (where 1 – extremely unimportant, 2 – unimportant, 3 – important, 4 – extremely important). After that the respondents had to choose 5 most important key constructs from the proposed list of key constructs associated with three transformative competencies.

The third part of the web-based questionnaire which included two open-ended questions was developed to ascertain present-day Ukrainian Computer Engineering and Information Technology undergraduates' views on what learning activities and academic disciplines were the most effective in developing transformative competencies during their training at university. Participants' responses to the open-ended questions included in the third part of the web-based questionnaire were generalized by means of content analysis method.

Since the paper aimed to reveal the didactic potential of humanities for developing Computer Engineering and Information Technology undergraduates' transformative competencies, the team of researchers used a purposeful sampling method to select respondents. After the web-based questionnaire was created, a link to it was purposefully distributed among undergraduates who specialise in Computer Engineering and Information Technology. As a results, the researchers received 275 completed questionnaires. The data collection lasted for two months from 3 October to 30 November 2022.

III. Results and Discussion

A. Gender Data

Table 1 demonstrates the gender data on online survey participants. The data in Table 1 below clearly shows that out of 275 Computer Engineering and Information Technology undergraduates who took part in the online survey, 84.3% were male and 15.7% were female. These data prove the fact that female Computer Engineering and Information Technology students continue to be under-represented in traditionally male occupations in Ukraine and such specialisations as Computer Engineering and Information Technologies are still the most popular among male students. These data also show that although the need for women in tech is growing every year, the number of female students graduating with a degree in computer science is not actually high in Ukraine.

Table 1 Gender Data on Online Survey Participants

Higher Education Institution	Number of Participants			
	Male		Female	
	Number	Percent	Number	Percent
Kyiv National University of Technologies and Design	57	20.7	12	4.4
Interregional Academy of Personnel Management	39	14.2	9	3.3
National Aviation University	49	17.8	7	2.6
Kyiv National Economic University named after Vadym Hetman	52	18.9	8	2.9
Kryvyi Rih National University	35	12.7	7	2.5

Source: own study (N=275)

Figure 1 illustrates the data on gender difference between online survey participants.

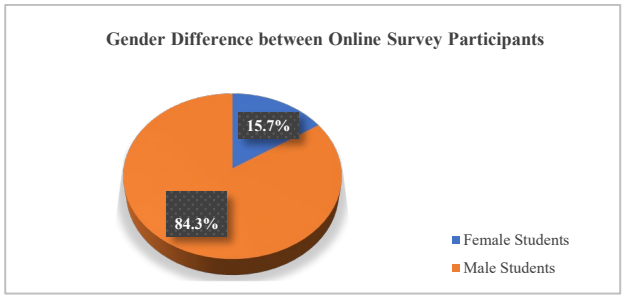

Fig. 1. Gender Difference between Online Survey Participants.

B. Awareness of Transformative Competencies

The results obtained demonstrate that 220 respondents (80.0%) were not knowledgeable about neither the concept of "transformative competencies" nor about three transformative competencies essential for changing the world for the better. 20 respondents (7.3%) stated that although they heard about this concept, they did not know exactly what it meant and they did not know that creating new value, reconciling conflicts and dilemmas, taking responsibility were considered to be three transformative competencies. 35 respondents (12.7%) found it difficult to answer this question.

Table 2 shows the data concerning respondents' views on importance of three transformative competencies for their future professional development and success.

Table 2 Respondents' Views on Importance of Three Transformative Competencies

Transformative Competencies	Extremely Important (%)	Important (%)	Unimportant (%)	Extremely Unimportant (%)
Creating New Value	34.9	54.9	10.2	0.0
Reconciling Tensions and Dilemmas	45.8	37.5	16.7	0.0
Taking Responsibility	50.2	44.7	5.1	0.0

Source: own study (N=275)

The results obtained show that although present-day Ukrainian Computer Engineering and Information Technology undergraduates were not familiar with the official definition of the concept of "transformative competencies" and the approach to classifying them on such competencies as creating new value, reconciling tensions and dilemmas and taking responsibility, they believed that they were of paramount importance for their further professional development and succeeding in the future. This can be proved by the fact that none of the respondents (0.0%) considered that creating new value, reconciling tensions and dilemmas and taking responsibility as three transformative competencies were extremely unimportant. 96 respondents (34.9%) pointed out that creating new value as a transformative competency was extremely important, 151 respondents

(54.9%) stated that it was important and only 28 respondents (10.2%) indicated that this transformative competency was unimportant. Reconciling tensions and dilemmas was considered extremely important by 126 respondents (45.8%) and important by 103 respondents (37.5%). 46 respondents (16.7%) believed that this competency was unimportant. What arouses sincere interest is the respondents' views on taking responsibility as a transformative competency. Thus, 138 respondents (50.2%) indicated that they found it as extremely important and 123 respondents (44.7%) considered it important. This transformative competency is regarded as unimportant by 14 respondents (5.1%).

The data concerning respondents' views on the importance of key constructs of transformative competency of "Creating New Value" for their future professional development and success are given in Table 3.

TABLE 3 RESPONDENTS' VIEWS ON IMPORTANCE OF KEY CONSTRUCTS OF "CREATING NEW VALUE"

Key Constructs of Creating New Value	Importance	
	Number	Percent
Sense of Purpose	213	77.5
Curiosity	78	28.4
Open Mindset	98	35.6
Critical Thinking	192	69.8
Creativity	226	82.2
Collaboration	198	72.0
Agility	88	32.0
Ability to Manage Risks	49	17.8
Adaptability	233	84.7

Source: own study (N=275)

From the results in Table 3, it is seen that respondents view adaptability (84.7%), creativity (82.2%), sense of purpose (77.5%), collaboration (72.0%) and critical thinking (69.8%) as 5 most important key constructs of creating new value as a transformative competency. Figure 2 illustrates the results concerning respondents' views on the importance of key constructs of the transformative competency of "Creating New Value".

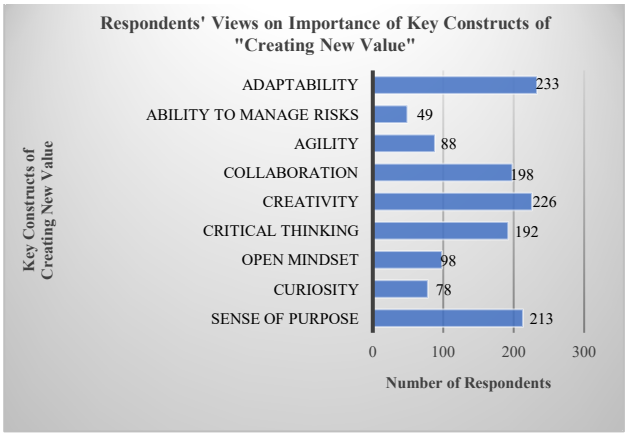

Fig. 2. Importance of Key Constructs of "Creating New Value" in Respondents' Opinion.

The data concerning respondents' views on the importance of key constructs of the transformative competency of "Reconciling Tensions and Dilemmas" for their future professional development and success are given in Table 4.

TABLE 4 RESPONDENTS' VIEWS ON IMPORTANCE OF KEY CONSTRUCTS OF "RECONCILING TENSIONS AND DILEMMAS"

Key Constructs of Reconciling Tensions and Dilemmas	Importance	
	Number	Percent
Cognitive Flexibility	81	29.5
Perspective-Taking Skills	211	76.7
Empathy	94	34.2
Respect for Others	170	61.8
Creativity	109	39.6
Problem-Solving Skills	149	54.2
Conflict Resolution Skills	191	69.5
Resilience	121	44.0
Tolerance for Complexity and Ambiguity	128	46.5
Sense of Responsibility	121	44.0

Source: own study (N=275)

The results, shown in Table 4, indicate that perspective-taking skills (76.7%), conflict resolutions skills (69.5%), respect for others (61.8%), problem-solving skills (54.2%) and tolerance for complexity and ambiguity (46.5%) are among 5 most important key constructs of reconciling tensions and dilemmas as a transformative competency. The researchers are inclined to consider that these key constructs were ranked high priority because they were hearing and respondents associated them with a person's ability to "to reconcile multiple and often conflicting ideas or positions, and recognise that there may be more than one solution or method to finding a solution" [9, p. 5].

The data on the research participants' views on the importance of key constructs of "Reconciling Tensions and Dilemmas" are summarised in Figure 3.

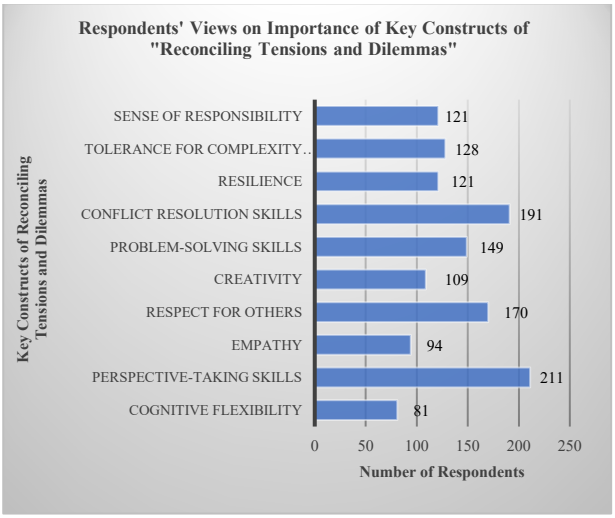

Fig. 3. Importance of Key Constructs of "Reconciling Tensions and Dilemas" in Respondents' Opinion.

The data concerning respondents' views on the importance of key constructs of the transformative competency of "Taking Responsibility" for their future professional development and success are given in Table 5.

TABLE 5 RESPONDENTS' VIEWS ON IMPORTANCE OF KEY CONSTRUCTS OF "TAKING RESPONSIBILITY"

Key Constructs of Taking Responsibility	Importance	
	Number	Percent
Locus of Control	97	35.2
Sense of Integrity	156	56.7
Compassion	109	39.6
Respect for Others	136	49.5
Critical Thinking	188	68.4
Self-Awareness	193	70.2
Self-Regulation	169	61.5
Reflective Thinking	175	63.6
Ability to Build Trust	152	55.3

Source: own study (N=275)

Figure 4 illustrates the data on respondents' views on the importance of key constructs of "Taking Responsibility" for them.

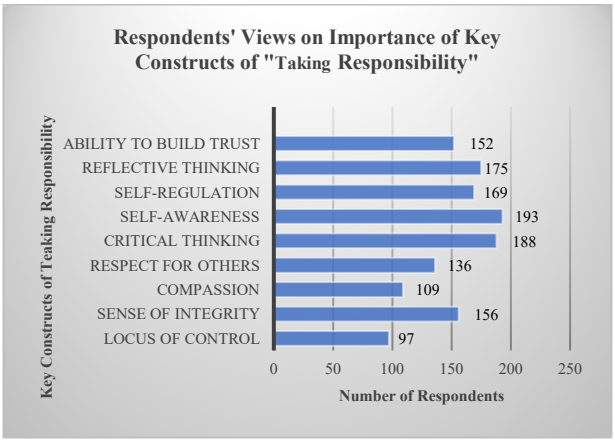

Fig. 4. Importance of Key Constructs of "Taking Responsibility" in Respondents' Opinion.

Thus, it can be seen that self-awareness (70.2%), critical thinking (68.4%), reflective thinking (63.6%), self-regulation (61.5%) and sense of integrity (56.7%) are ranked high and are among 5 most important key constructs of taking responsibility as a transformative competency.

C. Learning Activities and Academic Disciplines in Developing Transformative Competencies

It should be pointed out that the vast majority of respondents (84.7%) were of the opinion that transformative competencies could be developed by means of individual or group learning activities conducted in and outside the classroom

The results concerning learning activities which respondents considered the most effective in developing transformative competencies are given in Tables 6-7.

TABLE 6 RESPONDENTS' VIEWS ON INDIVIDUAL LEARNING ACTIVITIES EFFECTIVE IN DEVELOPING TRANSFORMATIVE `COMPETENCIES

Categories	Responses	
	Number	Percent
Project Preparations	173	74.2
Work on Presentations	202	86.7
Search for Information on the Topic	156	66.9
Free Writing Activities	89	38.2
Preparation of Abstracts or Conference Reports for Student Scientific Conferences	133	57.1
Writing Reflective Essays	64	27.5
Reflective Journals	37	15.9

Source: own study (N=233)

TABLE 7 RESPONDENTS' VIEWS ON GROUP LEARNING ACTIVITIES EFFECTIVE IN DEVELOPING TRANSFORMATIVE COMPETENCIES

Categories	Responses	
	Number	Percent
Project Preparations	173	74.2
Case Studies	105	45.1
Brainstorming Sessions	157	64.7
Games	73	31.3
Role Playing	57	24.5
Debates	92	39.5
Round Table Discussions	68	29.2
Participation in Olimpiads (competitions)	89	38.2
Extracurricular club activities	44	18.9

Source: own study (N=233)

The following excerpts from respondents' replies provide more information and thorough explanation on individual and group learning activities effective for developing key constructs associated with transformative competencies:

S27: *While completing this questionnaire, I learnt a lot of new information concerning transformative competencies and their key constructs. I think that there are many learning activities which can be useful in developing key constructs indicated in the questionnaire, to some extent. What I do believe is that our university teachers should combine learning activities which can be done individually or in groups (or in pairs) to develop transformative competencies and their key constructs. For instance, work on projects or presentations as well as search for information on definite topics involve studying various sources. It means that you should think critically to choose the most accurate and true information. What is more, doing these learning activities we learn to grasp new ideas or information. While preparing a presentation or a project like no other, we learn to think outside the box…*

S194: *I personally think that there is no single learning activity that works for everyone. I mean that some key constructs can be developed by means of individual learning activities and some of them can be developed by means of group learning activities. For instance, we won't be able to be collaborative and responsible, to show empathy and compassion if we do not work on joint projects. Participation in brainstorming sessions which involves teamwork can teach us to think outside the box*

and to take into consideration our groupmates' opinions. At the same time, writing reflective essays which requires individual work can help us to reflect on ourselves and our needs, to think about something that we did not think before. Reflective essays teach us to explore both our emotions and knowledge which we obtain while studying at university…

S263: *I haven't heard about transformative competencies before and now I know some information about them. I think our university teachers introduce some learning activities which are aimed at developing some key constructs of transformative competencies, for instance, a sense of responsibility, creativity, critical thinking, collaborative skills etc. But these learning activities are not aimed at simultaneous development of all key constructs of transformative competencies. I think, it is impossible to develop all of them during studying one discipline, the whole training course should be aimed at their forming and developing…*

The results obtained demonstrate that respondents understand quite clearly what learning activities can be used for developing investigated transformative competencies. Learning activities given in Tables 6-7 and pointed out by respondents enable us to state that the major methodological approach of Education 4.0 for developing transformative competencies among Computer Engineering and Information Technology undergraduates combines challenge-based learning (CBL) and activity-based learning (ABL).

It should also be noted that 42 respondents (15.3%) found it difficult to give a detailed reply to this question. Answering it they pointed out that the university lecturers should know it better what learning activities to apply in the classroom to develop investigated transformative competencies.

The findings concerning academic disciplines demonstrate that the majority of respondents (76.0%) considered humanities the most effective in developing transformative competencies. Among such academic disciplines respondents listed English and Ukrainian for Specific Purposes, Philosophy, Ukrainian studies etc. 14.2% of respondents expressed the view that technical disciplines were the most effective in developing transformative competencies while 9.8% of respondents found it difficult to answer this question. The results concerning humanities enable us to assume that these disciplines (1) are more likely to apply various learning activities which can be done both individually and in groups than technical disciplines and (2) have much broader potential for developing all key constructs of transformative competencies among Computer Engineering and Information Technology undergraduates than technical disciplines. But nevertheless, university lecturers who teach different academic disciplines to undergraduates who specialise in Computer Engineering and Information Technology should consider the possibility of creating favourable conditions for the full development of transformative competencies.

IV. Recommendations and Conclusions

The main idea for our research is that unpredictable events which are taking place in our rapidly evolving globalised world clearly demonstrate that the abilities to set clear and purposeful goals, effectively collaborate with others, find unexpected opportunities for successful self-realisation and, moreover, to identify multiple solutions to big problems are becoming a living reality. The results obtained reveal the didactic potential of humanities for developing Computer Engineering and Information Technology Undergraduates' transformative competencies and enable the researchers to formulate recommendations for university teachers of humanities on how to develop transformative competencies among Computer Engineering and Information Technology undergraduates:

1. We are inclined to consider that taking into account the transformative processes which take place in the present-day globalised society and the need to meet the perspectives and, what is more, frequently changing requirements on the labour market, university lecturers should raise students' awareness concerning transformative competencies and students should receive transformative competencies awareness education for shaping and contributing to a changing world through the content of academic discipline (disciplines) they study.

2. Equal importance should be paid to developing key constructs associated with investigated transformative competencies. Such an approach should be explained by the fact that each key construct within each transformative competency equally contributes to forming and developing professionals of the 21st century able to invent something new, to think outside the box, to make complex and difficult decisions and to take responsibility for their actions or total inaction. What is more, the obtained results concerning the respondents' views on the importance of key constructs associated with investigated transformative competencies point to the need to pay more attention to those key constructs which were ranked low.

3. To develop transformative competencies among students, university lecturers should use the entire spectrum of individual and group learning activities in and outside the classroom since each particular learning activity promotes the development of particular key constructs. The combination of challenge-based learning (CBL) and activity-based learning (ABL) is considered to be a major methodological approach of Education 4.0 for developing transformative competencies among Computer Engineering and Information Technology undergraduates.

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Developing Computer Engineering and Information Technology Undergraduates' Learner Autonomy: Individualised Instruction in English Classroom

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***Abstract*. The rapid development of information science and technology encourages lifelong learning and requires university graduates to be able to learn throughout their lives and have special abilities which help them search for continuous education and training opportunities. For students who associate their professional lives with computer sciences, learner autonomy is of immense importance since it helps them take full responsibility for success in professional life and career and contributes to the sustainable development of the current fast-moving digital society. As autonomous learners Computer Engineering and Information Technology undergraduates are able to define their goals clearly, to identify the most optimal learning strategies for achieving these goals and for acquiring new knowledge and skills necessary for their further professional development. The present study is aimed at finding out Computer Engineering and Information Technology undergraduates' viewpoints on effectiveness of individualised instruction for developing their learner autonomy in English classroom. With this in mind, the team of researchers applied a questionnaire to a sample of Computer Engineering and Information Technology undergraduates who study at three higher education institutions of Ukraine. Data collection lasted for three months and took place in September-December 2022. The obtained results clearly demonstrate that individualised instruction delivered through online teaching tools and apps in English classroom enables university teachers to develop Computer Engineering and Information Technology Undergraduates' learner autonomy effectively.**

Keywords: Computer Engineering and Information Technology undergraduates, English classroom, higher education institutions, learner autonomy, individualized learning.

I. INTRODUCTION

The rapid development of information science and technology encourages lifelong learning and requires university graduates to be able to learn throughout their lives and have special abilities which help them search for continuous education and training opportunities. To be competitive in the labour market, to keep expending their knowledge and learning new skills, the English language proficiency seems to be of significant advantage in the present-day globalised society [1] – [5]. Literature review shows that learner autonomy is believed to be important in mastering English among students of different ages and, moreover, of different specialties and, in this regard, Computer Engineering and Information Technology undergraduates are not an exception. Many scientists consider English as one of the most important 21st century skills for highly qualified professionals who work in the field of Computer Science or Information Technology and for whom English is not their native language [1] – [4]. K. Rajprasit & S. Hemchua indicate that "English language proficiency is vital for global computer engineers, from participating in the international professional arena and reaching a desirable position in terms of a career path, for

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example, job recruitment, routine work, promotion and advancement" [1, p. 109-110]. But it should also be noted that English as a discipline taught to Computer Engineering and Information Technology undergraduates is considered to be an effective medium for developing various job skills of tomorrow [5].

However, despite the obvious importance of learner autonomy, R. Smith opines that there are some restrictions in its developing among students [6].The researcher explains that it happens because entering the higher education institution, it is the institution itself or the university lecturer who determines the discipline's objective and contents, designs a syllabus for a course, chooses methods and techniques used in the classroom, pace of learning, evaluates educational achievements of students etc. [6]. But, nevertheless, students who want to succeed in life, understand the value of knowledge in the present-day globalised world and, what is more, recognize the value of keeping knowledge, have to learn to gain new experience and acquire new knowledge independently and to be able to do it through formal, non-formal and informal education [7]. It means that to stay on the top of the learning curve, students should be able to manage their own learning, learn to regulate their own learning process and be able to recognise the ongoing need to acquire new knowledge, skills and attitudes through identifying own learning strategies effective for achieving learning objectives. And, in this connection, developing learner autonomy is an essential requirement as it enables students of different specialties (including Computer Engineering and Information Technology undergraduates) to meet their learning challenges successfully and helps them reach their full potential.

Thus, for students who associate their professional lives with computer sciences, learner autonomy is of immense importance since it helps them take full responsibility for success in professional life and career and contributes to the sustainable development of the current fast-moving digital society. As autonomous learners, Computer Engineering and Information Technology undergraduates are able to define their goals clearly, to identify the most optimal learning strategies for achieving these goals and for acquiring new knowledge and skills necessary for their further professional development throughout their lives. We do believe that the present-day English classroom is an effective place for developing Computer Engineering and Information Technology undergraduates' learner autonomy through teaching students a lifelong love of learning and motivating them to acquire knowledge throughout their lives. What is more, the working arsenal of present-day English teachers contains a wide option of traditional and innovative online teaching and learning tools which enable them to successfully individualise instruction.

II. Literature Review

A. The Concept of "Learner Autonomy" in Scientific Literature

Literature analysis shows that the concept of "learner autonomy" which has been in scientific circulation for more than forty years has various definitions. One of the most cited definitions was introduced by Henry Holec who defined learner autonomy as "… the ability to take charge of one's own learning" [8, p. 3].

An interesting point of view is expressed by B. Ivanovska [9]. Considering autonomy as a multidimensional phenomenon (i.e., social, individual and cultural dimensions), the researcher argues that learner autonomy has to be interpreted as "a complex process in the frame of a cultural and in globalized context, too" [9. p. 355].

In the paper "Self-Efficacy, Autonomy and the Relationships Towards to English Achievement" S. Xiao points out that being conceptualised as a universal human need, autonomy plays an important role in adolescent development [4]. Investigating the connection between self-efficacy and autonomy in achieving success in learning the English language, the scientist claims that learner autonomy and self-efficacy are inextricably linked. Moreover, self-efficacy is considered to be "an influential variable on learner's autonomy" [4, p. 306].

Á. Scharle & A. Szabó define autonomy as "the freedom and ability to manage one's own affairs, which entails the right to make decisions as well" [10, p. 4]. The researchers are convinced that to foster learner autonomy it is not enough to develop a sense of responsibility among students. To become autonomous learners, students have to be actively involved in making decisions that concern their learning. Moreover, Á. Scharle & A. Szabó believe that students can turn into responsible and autonomous learners only on condition of realising and accepting the fact that they share the same responsibility for learning in general and learning outcomes in particular as their teachers [10].

K. Millsom defines learner autonomy as a "students' ability to learn by themselves, to take it upon themselves to develop their understanding without relying on the teacher, either for motivation or for easy answers" [11]. K. Millsom also believes that learner autonomy can be developed by means of introducing various individual and group activities [11].

Analysing scientific literature on autonomous learning, L. Xu comes to the conclusion that after its introduction into the scientific circulation, the concept of "learner autonomy" is still debated by researchers [12]. The scholar identifies three different approaches to defining the concept of "learner autonomy", namely: … "a personal characteristic, a political concept and a definition of educational practices" [12, p. 436]. In our research we accept the idea expressed by L. Xu that "… developing learner autonomy is a complicated project, which necessitates good coordination of various factors in the course of teaching and learning, such as changing ideas

about teachers' role and learners' role, redefining teachers' role in autonomous learning context, taking into account learners' individual differences in character, interests, needs, motivation, intelligence and use of learning strategies etc." [12, p. 435].

Considering autonomy as "a step-by-step process which consists of several phases, stages or levels" [13, p. 133], B. Horvathova claims that the core of the learner autonomy is manifested in the learner's "ability to make informed decision and choices …" [13, p. 133].

Taking into account the analysed approaches to defining the concept of "learner autonomy", we define learner autonomy as a person's ability and readiness to be open to new opportunities, challenges and experiences throughout life with the purpose of personal and professional fulfillment. It means that to be autonomous, a person has to be able and ready (1) to take the initiative and the full responsibility for personal and professional development including acquiring and mastering knowledge and skills throughout life; (2) to adequately evaluate the level of knowledge and skills necessary for solving personal and/or professional tasks; (3) to reflect upon knowledge and skills gained through formal, non-formal and informal education; (4) to identify existing gaps in knowledge and skills necessary for solving personal and/or professional tasks and to fill them successfully; (5) to identify learning strategies effective for acquiring and/or mastering knowledge and skills necessary for solving personal and/or professional tasks; (6) to consider individual characteristics, interests and needs to develop himself/herself to his/her full potential; (7) to consider challenges as opportunities for personal and professional development.

B. Individualised Instruction

The analysis of the relevant literature demonstrates that in order to meet interests, needs and preferences of students of different ages and to turn them into active and responsible lifelong learners, teachers should enhance their teaching with individualized instruction [14] – [18]. It means that the choice of approaches, methods and techniques teachers use both in and outside the classroom should address the real needs of students and should be geared towards their equipping with a wide range of competences and skills.

Trying to find out what individualised instruction is, R. L. Collins emphasises his attention on two ideas that are the basis for understanding this concept [16]. Thus, according to the first idea, individualised instruction should be based on students' learning styles. The second idea is that instruction should be indivisualised considering gaps in each student's knowledge.

Reflecting on the similarities and differentces between differentiated and individualised instruction, K.-T. Lindnera & S. Schwab come to the conclusion that both of them have a great didactic potential in meeting students' individual needs. But, at the same time, the researchers admit that individualised instruction "respects individual needs of students more on a micro level and is paced to the educational needs of individual students" [17, p. 3].

Considering learning as "a stable and persistent change in what a person knows and can do" [18, p. 1], A. Shemshack and J. M. Spector suggest that "individualized instruction is one of the terms that are often used to talk about the specific needs and goals of individuals to be addressed during instruction" [18 p. 5].

Individualised instruction is also defined as a learning process "where students' personal needs are placed at the forefront of an instructor's teaching practices" [19].

In our research we define individualised instruction as instruction that promotes either gaining or mastering students' theoretical knowledge and practical skills (including filling the gaps in their knowledge or skills) on the basis of their individual and psychological peculiarities, needs or interests.

III. Materials and Methods

The present study is aimed at finding out Computer Engineering and Information Technology undergraduates' viewpoints on effectiveness of individualised instruction for developing their learner autonomy in English classroom.

The research was focused on Computer Engineering and Information Technology undergraduates and was carried out at three higher education institutions of Ukraine (namely, Kyiv National University of Technologies and Design, Interregional Academy of Personnel Management and Kryvyi Rih National University). The research sample consisted of 177 Computer Engineering and Information Technology undergraduates (82 respondents – first year students (46.3%), 29 – second year students (16.4%), 37 – third year students (20.9%), 29 – fourth year students (16.4%)). It should be also mentioned that the research sample included 153 male students (86.4%) and 24 female students (13.6%).

To reach the aim of the study, the researchers developed a web-based questionnaire using Google Forms based on the analysed approaches to defining the concept of "learner autonomy" and the concept of individualised instruction". To find out respondents' viewpoints on effectiveness of individualised instruction for developing their learner autonomy in English classroom, the web-based questionnaire contained 4 statements for rating on a 4-Likert scale (from 1, strongly disagree, to 4, strongly agree), 1 close-ended question and 2 open-ended questions. Respondents were also asked to substantiate their views on statements offered for rating. Data collection lasted for three months and took place in September-December 2022.

The close-ended question was worded as follows:

Can you call yourself an autonomous learner?

The open-ended questions were worded as follows:

What is autonomous learning?

What activities do you consider effective for developing your learner autonomy in English classroom?

The respondents were asked to rate the following twelve statements:

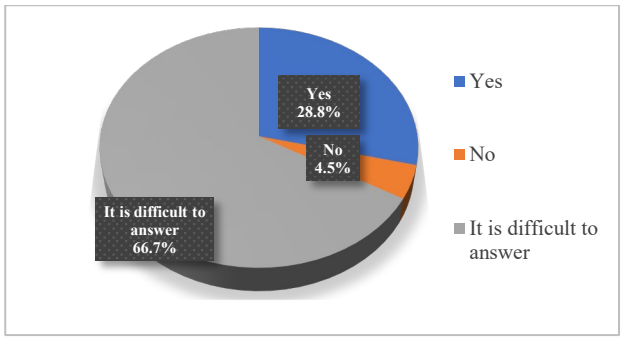
1. *To develop learner autonomy university teachers have to consider students' interests and needs in the learning process.*
2. *To develop learner autonomy university teachers have to consider students' initial knowledge in the learning process.*
3. *To develop learner autonomy university teachers have to consider students' individual characteristics (including predominant perception channels, namely, visual, auditory and kinesthetic) in the learning process.*
4. *University teachers have to use a wide range of online teaching tools and apps to motivate students to gain knowledge independently.*

The research design was mixed and included qualitative and quantitative processing of the data obtained.

IV. Results

The first question of our web-based questionnaire was "*What is autonomous learning*?". Replying to it, 29 respondents (16.4%) stated that they found it difficult to explain what it was. 148 respondents gave various explanations of what they considered autonomous learning was. The majority respondents (44.6%) understood autonomous learning as a self-directed way of gaining new knowledge and skills or mastering them. Here are some excerpts from their replies: "… *when students know exactly what learning outcomes they are expected to learn in a course and are given freedom to gain necessary knowledge and skills* …" (Respondent No. 2); "*In my opinion, autonomous learning is when students are able to gain knowledge without teachers' help …* " (Respondent No 5). Some respondents (21.5%) believed that autonomous learning is a way of managing own time while doing a task: "… *autonomous learning is when you are assigned a task (an individual project, working on presentation etc.) and given a deadline and you manage your own time to complete it. I mean when you know when the deadline is you can start doing something immediately or you, for instance, can postpone doing it to the last moment. You are the one who decides what to do. The more important is the result, I think….* " (Respondents No. 23). Some respondents (10.7%) pointed out that autonomous learning is students' ability to self-monitor the knowledge gained during the course: " … *how to self-monitor knowledge and understand where there is a gap*…" (Respondent No. 147). And for some respondents (6.8%) autonomous learning is a way of identifying learning strategies effective for acquiring and/or mastering knowledge and skills. Here is one of the most detailed excerpts: "*I think autonomous learning is when knowing your strengths and weaknesses (I mean some theoretical knowledge or practical skills you have) you try to find your own way of improving your weaknesses and do not forget to exercise your strengths*…" (Respondent No. 93). The results obtained show that although respondents understand to some extent what autonomous learning is, no one relates it to the person's ability and readiness to gain knowledge and skills necessary for personal and professional fulfillment throughout life.

The second question was aimed at finding out whether the respondents consider themselves autonomous learners. The results obtained clearly indicate that only 28.8% of respondents considered themselves autonomous learners, 66.7% of respondents found it difficult to answer this question and 4.5% of respondents replied negatively answering this question. Figure 1 provides a visual display of parents' opinions on signs of anxiety among their children of different school ages.



Source: own study

Fig. 1. Respondents' views on whether they consider themselves autonomous learners.

Table 1 shows the data concerning respondents' views on effectiveness of individualised instruction for developing their learner autonomy in English classroom.

TABLE 1 RESPONDENTS' VIEWS ON IMPORTANCE OF THREE TRANSFORMATIVE COMPETENCIES

Statements	Strongly disagree (%)	Disagree (%)	Agree (%)	Strongly Agree (%)
To develop learner autonomy university teachers have to consider students' interests and needs in the learning process	0.0	0.0	51.9	48.1
To develop learner autonomy university teachers have to consider students' initial knowledge in the learning process	0.0	0.0	42.9	57.1
To develop learner autonomy university teachers have to consider students' individual characteristics (including predominant perception channels, namely, visual, auditory and kinesthetic) in the learning process	0.0	0.0	35.6	64.4
University teachers have to use a wide range of online teaching tools and apps to motivate students to gain knowledge independently	0.0	0.0	24.3	75.7

Source: own study (N=177)

The results in Table 1 clearly demonstrate that the 51.9% of respondents agree and 48.1% of respondents strongly agree with the fact that to develop learner autonomy university teachers have to consider students' interests and needs in the learning process. Substantiating their views on the first statement, the respondents explain that when university teachers consider their interests, support and encourage their development, they feel motivated and do not want to stop on the achieved results. Considering students' interests and needs in educational process also helps to build trust and a good rapport between students and teachers which enables them to more effectively communicate in the classroom. 42.9% of respondents agree and 57.1% of respondents strongly agree that to develop learner autonomy university teachers have to consider students' initial knowledge in the learning process. Explaining their point of view on the second statement, the respondents explain that it is desirable to take into account their initial knowledge in the learning process. They also mention that if you are not used to learn independently and you find it hard to reflect on knowledge you lack or, what is more believable, you are not ready to make some efforts to fill in these gaps independently, teachers' assistance is of great importance. You are not fully capable of assimilating more complex material if you lack some basic knowledge, on the one side, and, on the other side, some gaps in knowledge which are not filled in cause more serious problems connected with your confidence. That is why, when teachers know that university students' have some gaps in knowledge, they can help fill in these gaps providing some learning materials for self-studying and/or involving them in some activities aimed at gaining this knowledge independently. 35.6% of respondents agree and 64.4% of respondents strongly agree that to develop learner autonomy university teachers have to consider students' individual characteristics (including predominant perception channels, namely, visual, auditory and kinesthetic) in the learning process. The analysis of the respondents' responses on this statement shows that they do believe that considering their individual characteristics in the learning process is important. The respondents point out that nowadays university teachers present learning material in various ways (i.e., presentations, video-lessons, pre-class homework etc.) which enables to influence all perception channels. Moreover, activities which are often used in the English language classroom are aimed at developing four language skills (i.e., reading skills, listening skills, writing skills and speaking skills) and involve all channels of perception of information. And 24.3% of respondents agree and 75.7% of respondents strongly agree that to motivate students to gain knowledge independently university teachers have to use a wide range of online teaching tools and apps. Justifying their perspectives, the respondents state that various online resources with up-do-date information, online platforms and applications with interactive activities can stimulate at once several perception channels and their use in the English language classroom enables teachers to keep students motivated. What is more, they believe that multiple performing some interactive activities inspires them to gain knowledge independently and encourages them to continue practicing. In their replies the respondents list various online platforms and applications used during their English classes, namely, Learn English Online by British Council (https://learnenglish.britishcouncil.org/), Breaking News English (https://breakingnewsenglish.com/), BBC Learning English (https://www.bbc.co.uk/learningenglish), Daily Grammar (https://www.dailygrammar.com/index.html), Ted (https://www.ted.com/), Kahoot, Online Board Miro, Google Classroom etc.

To identify activities considered effective for developing learner autonomy in English classroom, the researchers use the content analysis method. Table 2 demonstrates the obtained results.

TABLE 2 RESPONDENTS' VIEWS ON ACTIVITES EFFECTIVE FOR DEVELOPING LEARNER AUTONOMY IN ENGLISH CLASSROOM

Categories	Number (N)	Percentage (%)
Individual tasks according to students' individual characteristics (including predominant perception channels, namely, visual, auditory and kinesthetic), interests and needs	134	75.7
Pair work	41	40.1
Small group work	68	38.4
Work in big groups or teams	56	31.6
Activities based on the use of online tools	159	89.8

Source: own study (N=177)

The results in the Table 2 show that the majority of respondents (40.1%) believed that the most effective activities used in the English language classroom were connected with doing individual tasks according to their either individual characteristics (including predominant perception channels, namely, visual, auditory and kinesthetic) or their interests and needs. 40.1% of respondents pointed out that working in pairs while learning English promotes effective development of learner autonomy. Small group work was considered to be effective in developing learner autonomy by 38.4% of respondents and work in big groups or teams by 31.6% of respondents. What is also interesting is that 89.8% of respondents point out that activities based on the use of online tools in the English language classroom are effective in developing learner autonomy.

V. CONCLUSIONS

The present study is aimed at finding out Computer Engineering and Information Technology undergraduates' viewpoints on effectiveness of individualised instruction for developing their learner autonomy in English classroom. The obtained results clearly demonstrate that

individualised instruction delivered through online teaching tools and apps in English classroom enables university teachers to develop Computer Engineering and Information Technology Undergraduates' learner autonomy effectively. At a much broader level, the ideas arisen during our research can be generalised and represented as two teaching strategies to be implied as a result of investigating both individual and psychological peculiarities of students and their corresponding activities used in the English language classroom aimed at developing learner autonomy as a particular issue and on the way of mastering English as a more general issue. Thus, we can assume that investigating individual and psychological peculiarities of students which can directly or indirectly influence the achieving of best learning outcomes is the background for realisation of didactic potential of the English language classroom. That implies the implementation of two teaching strategies aimed at developing students' learner autonomy, on the one side, and, on the other side, mastering the English language as a whole. The first teaching strategy presupposes the utmost use of predominant perception channels (i.e., visual, auditory and kinesthetic) for accumulating specific subject- and language-content. The second teaching strategy presupposes the use of rationally-balanced combinations of tasks and assignments actively used in the process of learning English as ones that could compensate and enhance the less developed perception channels while accumulating specific subject- and language-content.

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Teachers' Data Literacy Skills for Pedagogical Decision Making: Needs Analysis in Lithuania and Germany

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***Abstract*. The purpose of the article is to analyse the needs of general education schoolteachers' data literacy skills that are important for the effective use of learning analytics in the teaching-learning process. The theoretical part of the article presents the idea of big data in education, highlights the aspects of pedagogical value of learning analytics technologies, provides the overview of learning analytic tools. Some overview and comparison of spread of learning analytics tools in general education schools in Lithuania and Germany is presented in the context of data-driven education. The empirical part of the article presents some results from a big qualitative study of teachers' experiences applying learning analytics tools in teaching - learning process. The main question of the current research is what data literacy skills teachers need in order to use learning analytics tools and make data based pedagogical decisions. Semi-structured interviews were conducted with 10 Lithuanian and 9 German teachers from general education schools, who already have had experience in working with learning experience platforms (digital learning platforms that integrate learning analytics tools). Interview data were analysed by means of content analysis. The results of the qualitative study showed that in order to use learning analytics tools it is important for teachers to have such skills as: digital literacy, data collection, data analysis and interpretation, etc. Comparative analysis of informants' answers showed that teachers in Lithuania and Germany expressed similar needs for data literacy skills.**

Keywords: Learning analytics, teachers' data literacy, needs analysis in Germany and Lithuania

I. INTRODUCTION

In the last decade, the paradigm shift from accountability-based education to data-based education, which focuses on continuous improvement, has put a strong emphasis on the purposeful use of data to improve the quality of education in European countries [1], [2]. Although data in education are still a relatively new phenomenon, the value of information obtained from data analytics is unique. From a research point of view, this is a promising opportunity to contribute to the personalization of student learning, as well as to the formation of educational policy.

The recent trend in digitalisation of education has fostered the rapid development of educational technologies (EdTech) such as computer-based learning environments, adaptive learning technologies, intelligent learning systems, "smart classrooms" and other. These technologies

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generate a lot of data about learners. These data may include simple/uncomplicated data such as time spent in a virtual environment or learning system or time spent on tasks. More complex data include various indicators of task resolution. These data are often digital, but often include text, images and video, and is often temporary in nature, capturing the interactions of system users during individual or group learning, as well as the longer-term learning plans of learners. Based on the named data characteristics, these data are classified as big data. Big data collected during the learning process are the domain of learning analytics [3], [4], [5].

Learning analytics has the greatest capacity to provide useful insights needed to make pedagogical decisions and to improve the quality of student learning [6]. Learning analytics technologies leave the decision-making to the human, but back it up with automated data analysis, possibly using AI techniques. In this way, the overall goal of learning analytics is to aggregate/accumulate data from various educational environments, perform their analysis, so that people can use the data to improve the solutions.

According to researchers, one of the main beneficiary groups of learning analytics data are teachers [7], on the other hand, it is teachers' readiness to use data to improve pedagogical activities and decisions that connects the essence of data analytics with the needs of educational theory and practice, educational content and understanding of how students learn [7], [8].

Research carried out in Germany [9] points that in data-driven schools the concept of and need for teachers' data literacy is expressed [10]. Research conducted in Lithuania [11] shows that Lithuanian schools create and accumulate data in different environments, but teachers require special knowledge and skills for analysis.

Asserting that teachers' use of data makes them more efficient in pedagogical practice immediately raises the question of how to unleash this potential. Therefore, the current study is timely and relevant effort aimed at filling the gap in scientific insights, helping to disclose the relevant data literacy needs of teachers in general education schools in Germany and Lithuania, responding to the priorities of educational and educational strategic documents in Germany and Lithuania [13] teacher education and professional development goals.

II. Big Data and Learning Analytics in General Education Schools

The integration of big data aggregation technologies into digital education tools has several advantages for education [14]:

- Personalization of learning: big data can lead to personalized learning, which goes beyond adapting pedagogical methods or tasks to the specific learning needs of students, but enables learners to design their own learning based on how they learn, what their learning needs are, what their learning goals are, aspirations and even according to the socio-cultural background of the learners [15].

- Adaptive learning: adaptive learning systems can continuously collect and interpret student data, change the direction and environment of students' learning, taking into account their needs and abilities [16].

- Accurate assessment: big data make it possible to monitor students in their learning process, so it is possible to apply new assessment methods that more accurately assess student achievements [17].

- Effective feedback: big data can help ensure a more reasonable and effective feedback cycle - students receive feedback in real time and based on their real contribution [18].

- Learning prediction: student behaviour, skills and learning outcomes can be predicted based on the analysis of student activities on digital platforms. This is also important for teachers - they can pay more attention to students with specific learning gaps [19].

In response to the emergence of big data in education learning analytics has become a rapidly developing field that includes learning analytics as a research field and learning analytics as a practical application field [12]. The focus on learning data analysis has opened a whole new field of educational research and provided an opportunity to reconsider how this type of analytics can help improve the content of a teaching/learning subject and improve the teaching and learning process in a technology-based learning environment [21]. Learning data analytics has become a new practice concept in educational institutions. According to [22] this is a new and promising method that expands practitioners' knowledge about the teaching and learning process.

The beneficiaries of learning analytics technologies first of all are teachers who want to analyse their classroom situations in more detail [7]. Learning analytics tools allow teachers to form timely and meaningful assessments of ongoing learning activities. Learning analytics tools increase teachers' understanding of student achievement [23],[24], potential misconceptions (e.g. guess correct answers) [23] approved curricula and training effectiveness [25]. Learning analytics can inform teachers about the quality of instructional content and the impact of teacher-proposed activities and the effectiveness of their assessment process [26]. Teachers can use these data to learn how students are learning and what their main strengths and weaknesses are. Based on fine-grained evidence, such as the level of computer-based assessment skills, engagement in activities, etc., teachers can also make important pedagogical decisions. These fine-grained data are also important for monitoring performance changes [27]. Teachers can effectively use detailed information about students' knowledge gaps in different subject areas. Information about a student's strengths and weaknesses could be used by the teacher to plan interventions where the student needs help moving forward. In this way, learning analytics tools can help teachers highlight students who may need extra help [28], [29], [30] or reflect on different

ways to encourage students to learn further [29]. On the other hand, learning analytics tools can assist teachers in considering the design and development of new course programs [31] and help them improve the quality of digital textbooks and instructional materials [32]. Many educators strongly believe that, when used properly, learning analytics can be an essential tool for closing the achievement gap, increasing student success, and improving the quality of education in the digital age [7].

III. TEACHERS' DATA LITERACY SKILLS AND LEARNING ANALYTICS

It was proven by research studies that data-informed decision-making can contribute to better student achievement [34], [35], [36]. However, to reveal the full potential of data in education, more scientific insights are needed on how exactly teachers could effectively use data in their pedagogical practice [35]. In education research, the concept of teacher data literacy competence has evolved from a focus on the skills that teachers need to engage in, collect, analyse and interpret instructional data and perform data-based pedagogical actions [37]. Teachers need competencies to interpret data and combine it with their pedagogical knowledge to benefit educational practice [38].

The problem of data literacy among general education teachers is relatively new [39], but there are already scientifically based arguments that teachers lack data literacy and that actions are needed to improve this situation [40]. A key concern is to find a way how to empower teachers to effectively apply data to improve instruction [41], [42]. The results of other studies [43] emphasize the need to develop teachers' competencies to effectively use data for pedagogical decisions. Corrin et al. [44], who conducted an experiment with a group of teachers, found that the participants in the study lacked the competence to correctly interpret the data. Herodotus et al. [45] research revealed that it was difficult for teachers participating in the study to plan appropriate pedagogical interventions based on the data. [46] research highlighted the need for teacher competence development in the field of data analytics application.

In addition, general education schools are increasingly using digital learning environments [47], so the focus of research in recent years has been on the introduction of data generated by these environments into the decision-making process of teachers and their effective use [49]; [48] emphasize the need to help teachers master data-driven technologies. According to [51] effective use depends on various components - general characteristics of teachers, such as technological skills, age, gender, as well as their pedagogical knowledge, professional routines, ability to understand and interpret data, etc. There is a lack of scientific research on how these factors interact and what impact they have on pedagogical practice and the teaching/learning process.

[52] report that research on learning analytics in Germany is scarce and that there are only a few projects focusing on the implementation of learning analytics systems. Since 2019 several research projects have been funded by the German Federal Ministry of Education and Research focusing on technology integration and analytics in educational organizations [53]. For example, the aim of the project 'Utilizing Learning Analytics for Study Success' is to conduct a systematic review and construct a set of policies for German education institutions to adopt learning analytics capabilities into their existing learning environments. However, it became evident from the integrative review that robust empirical findings on a large scale to support the effectiveness of learning analytics actually retaining students onto courses are still lacking [52]. The project findings of the interview study indicate that more work on ethical and privacy guidelines supporting a wider adoption of learning analytics systems is needed as well as work towards a standardized learning analytics system which can be integrated into any learning environment providing reliable at-risk student prediction, prevention and intervention strategies [56]. In particular, personalized learning environments are increasingly demanded and valued in education institutions to create a tailored learning package optimized for each individual learner based on their personal profile which could contain information such as their geo-social demographic backgrounds, their previous qualifications, how they engaged in the recruitment journey, their activities on social media and websites, as well as tracking information on their searches [57]. Besides the technological challenges, teachers' capabilities are also changing when implementing learning analytics systems. Not only new teachers' roles but also further professional development of teachers is required for successful implementation of learning analytics systems [55].

In Lithuania, it can be said that two ambitious educational projects have been implemented and their harmony and common pedagogical direction is extremely important for the digital transformation of education. The project "Creating and implementing digital educational content" [59] has an aspiration to update education programs and the results of the update will be described and placed in a virtual environment so that teachers can use them to monitor individual student progress and provide support. In addition, it is planned to update already created digital teaching resources and to create and adapt open digital teaching resources, which are needed for the implementation of updated common programs. The project "Artificial intelligence in schools: scenarios for the development of learning analytics while modernizing general education in Lithuania" [65] focused on the benefits of learning experience platforms in general education schools particularly putting the emphasis on use of learning analytics in teachers' practice. [11], [61] studies conducted in Lithuanian general education schools showed that teachers have not relevant skills for working with data, and moreover, they feel a lack of such skills. However, at the moment, there is a lack of more detailed research in Lithuania, dedicated to the issues of teachers' data literacy competence and its development. In addition, in Lithuania, research related to digital student data, digital data analytics

tools, ethical issues of data collection and use, etc. was not detected.

IV. DESIGN OF THE EMPIRIC STUDY

The goal of the empiric study was to disclose the teachers' needs for digital literacy skills in school of Germany and Lithuania.

To achieve this goal - individual interviews with teachers, who use the educational platforms that integrate learning analytics in their pedagogical practice, have been carried out. In Lithuanian general education schools, we have interviewed teachers that use the following platforms that integrate learning analytics and artificial intelligence: EdutenPlayground, Matific, FastForWord, Egzaminatorius.LT, EduAI [60]. In Germany – Stemify, Möbius.

The research population was formed using criterion selection [12]. Teachers with at least one year of experience working with this type of platform were selected as the study population. The form of selection of the sample of research participants was a convenient targeted sampling. The purpose of the convenient targeted sampling in this case was to include into the study group those informants, who are the most typical representatives in terms of the required characteristics. A total of 19 semi-structured interviews were conducted.

The data collection instrument consists of open-ended questions divided into several diagnostic blocks designed to reveal teachers' opinions about their work with learning analytics tools and the needs for certain skills to use learning analytics tool effectively.

Qualitative content analysis was chosen as a method for analysing written, verbal and visual communication messages [62] for the analysis of interview data and the presentation of research findings. Classical content analysis involves the techniques of reducing text into groups based on codes composed of variables (presence, intensity, or quantity of significant characteristics) [63]. Data analysis was carried out in several stages: 1. reading the interview text; 2. categorization based on essential words; 3. dividing the content of categories into subcategories; 4. description and justification of categories and subcategories with evidence extracted from the text [64].

V. IMPLEMENTATIONS AND DISCUSSION

After analysis of the research results the following categories have been formed: technology management skills, skills of interpreting data summaries received from learning analytics, skills to analyse student learning, the need for competence development, and leadership skills in learning analytics. The following categories represent the teachers' skills in using learning analytics tools in Lithuania (table 1).

TABLE I. Teachers' skills in using learning analytics tools in Lithuania.

Category	Subcategory	Illustrative thesis
Teachers' skills in using learning analytics tools	Technology management skills	"First of all, we have to master the technology. I understand that not everyone likes it, some people are still afraid of them (technology)." (No. 2)
	Skills of interpreting data summaries received from learning analytics	"... additional training for teachers on how to study and analyze statistics, because a lot of statistics are presented and especially that skills map is fascinating, but I personally do not have enough skills, well, that system is sometimes difficult to understand." (No. 4)
	Skills to analyze student learning	"...the teacher's ability to analyze children's learning is important. If until now it has been scattered knowledge, now I have it and can look at it digitized, at any time I can open the last lesson, even the lesson at the beginning of the year, and see how the child did in this or that topic. We, the teachers, are not learning analysts, as far as we can manage it, either on paper or in Excel, so we do need skills to compare what is presented." (No. 7)
	The need for competence development	"But the teacher has yet to be trained. Because the teacher can manage, raise the bar, help to jump according to each, this is where the personalization is - according to each child..." (No. 6)
	Leadership skills in learning analytics	"we started with teachers who are pioneers, who are more forward looking and have more enthusiasm for these things, we started with them. Then the other teachers started watching - "What are you doing there?" It looks pretty good, pretty fun, how can we get in on it?" (No. 3).

When talking about teachers' skills in using learning analytics tools, the informants emphasized ICT management skills. In their words, teachers should first of all be "technology-friendly" - they must want to apply technology in the teaching/learning process and manage it effectively. "*Not everyone likes working with computers and some find it counterproductive, but applying learning analytics requires skills of technology usage.*" (No. 5) Informants acknowledged that among teachers there are doubts about the benefits of integrating technology into education.

Research participants also emphasized that in order to successfully use learning analytics, you need to have the ability to interpret data summaries and statistics. <...> *we face the problem of data analysis and interpretation, we see that it is really difficult to read the graphs, although we really make them very simple, but it is simply difficult. <...>We see that this skill [data analysis] is not very strongly developed.* (No. 10.) As a result, it is important to be able to understand the "outcome" of learning analytics - in which pieces of data analysis are presented, to

understand how it can help answer various questions related to the learning process.

In addition, according to the informants, it is important to be able to interpret data and connect them with opportunities for improving the learning process. Such teacher' skills would promote data-based pedagogical decisions. "<…> *now I have it and can look at it digitized, at any time I can open the last lesson, even the lesson at the beginning of the year, and see how the child did in this or that topic"* (No. 9).

Another important aspect emphasized by the research participants is the need for the development of skills to use learning analytics. <...> *learning on the program [name of the program] is about strengthening self-knowledge and the ability to learn. (*No. 10).

Moreover, leadership appears to be a very important skill to apply learning analytics programmes at schools "*we followed teachers, teachers who were pioneers came to us, they started using, and slowly other teachers started using. So there were teachers who convinced other teachers that this was actually a good thing"* (Nr.3). In the opinion of the informants, the most important factor that can influence the wider use of learning analytics in Lithuanian schools is teacher training and support for teachers on how to apply these technologies in the educational process.

Some similar results appeared in the interviews with German teachers. Main skills in using learning analytics tools in Germany are: computer literacy, data collection skills, skills in data analysis, competence in learning to learn and openness to innovation.

TABLE II. Teachers' skills in using learning analytics tools in Germany

Category	Subcategory	Illustrative thesis
Teachers' skills in using learning analytics tools	Computer literacy	"Most likely, children are superior to us in digital, although sometimes I start to doubt it, because the teachers are really competent enough, but for the most part it is true. Children know how to play games, but there has been no purposeful use of IT for learning for a long time "(No. 11)
	Data collection skills	<…> we have to learn to collect the data that is needed. Don't pick just any and be happy that you have the data". (No. 12).
	Skills in data analysis	"Now about analytics with data, I think it's very new, fairly new, although it should be, maybe I'm not quite right, maybe working with data has been around for a long time, but very specifically, with such precision and such detail, how much time is spent, what tasks etc. i.e. and that it can be presented to the parent and that the teacher and the child can see, that's new enough" (No. 12)
	Ability to learn and openness to innovation despite the age	"<...> [the teacher] is so receptive to innovations, technologies, who are not afraid of the computer, and cannot say whether they are younger or older, there are certainly older people who use it very well, you cannot predict the age limit and you cannot say that only young people, but maybe it depends on the teacher himself" (No. 14).

Computer literacy remains one of the most significant skills needed to work with learning analytics platforms. This skill has grown significantly with the advent of distance learning. *"<...> technological literacy of teachers, it seems to me, has grown in half a year, in reality such a situation has happened that many things have really improved, some are more difficult, others are much easier, but it seems to me that this is still a situation from which something has come out good* (No. 11.)

Competence in data collection and its low level were not relevant for teachers until they started using learning analytics platforms, as confirmed by the research participants. The results of the study showed that teachers often independently collected chaotic data without a system, without planning the purpose and purpose of its use. *"<...> we now have a lot of data about our students' learning, but we need skills how to decode it and link to pedagogical decisions".*

Data collection is closely related to the competence of data analysis and interpretation, which, as the research participants noticed, was very lacking when learning analytics started to work. <...>*because a lot of statistics are presented and especially that skill map is fascinating, but I personally [don't have enough] skills, well, that system is sometimes difficult to understand*. (No. 12). The development of data analysis competence is a part of the computer literacy competence (data management), but this competence is still lacking. As noted by the research participants, supporting the use of learning analytics platforms required filling in missing knowledge. It is important to mention that the study participants observed an increase in this comparison after starting to use learning analytics tools. In other words, working with the learning experience platforms (including training for working with learning analytics) has contributed to the improvement of this competence.

Ability to learn and openness to innovation are understood as the need to learn and persistent pursuit of a set goal, responsibility for one's learning; abilities to plan and reflect on the learning process and results, set measured further tasks, choose learning methods; knowing one's strengths and weaknesses, being interested in learning options. Research participants mentioned that *"<...> learning analytics impowers us to become teachers-researchers, I mean, to carry out own research and use results for the self-improvement".* However, as research participants stated, teachers themselves still lack this competence, especially when it comes to new digital learning tools (including learning analytics).

All in all, after analysing the research data, it can be seen that the application of learning analytics strongly depends on the skills of teachers and may be problematic if they are limited. The results of the study showed that teachers who are more open to innovation and are seeking to learn something new, constantly researching and interested, tend to use learning analytics platforms much more actively. Research participants emphasized that teachers need to be able to interpret the data generated by those tools and combine them with their own pedagogical knowledge in order to benefit educational practice. Data literacy skills include the ability of teachers to: understand what data are needed to solve a particular problem, collect these data, understand (student) data presentation and feedback provided by learning analytics tools, use these data and inform their decisions to provide better support for students. Research shows that teachers often lack the skills to analyse data and apply the results of such analysis in practice, as well as teachers lack the ability to set specific goals, collect data and plan interventions to achieve that goal. The research emphasizes that teachers need to acquire a certain level of data literacy, which means the ability to transform information into practical knowledge and practice by collecting, analysing and interpreting all types of data, and also to implement certain pedagogical actions on the basis of such analysis. It combines the essence of data analytics with educational theory and practice, educational content and an understanding of how students learn. Therefore teachers feel the need to become teachers-researchers, who are able to raise problematic question, collect necessary data, analyse and interpret it and to take data-based decisions to solve the issue. These skills should be in the focus of teacher training and professional development programmes in Germany and Lithuania. Also, comparative analysis of informants' answers showed that teachers in Lithuania and Germany expressed similar needs for data literacy skills.

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Lifelong Learning for Talent Management and Professional Development of Employees

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Abstract. **The new challenges in almost all organisations are based on people. It is their competences, knowledge and skills that enable any organisation to grow. Personnel are a resource that must be properly taken care of. Effective talent management is mainly based on planning and building career paths. Talent management is one of the most important business priorities for organisations that care about achieving business goals, knowledge management and managing staff potential. Research shows that entities that identify and manage talent produce 15 per cent higher results for their stakeholders compared to pillars that do not run such programmes.**
The aim of this article is to present the activities carried out within the framework of TALENT MANAGEMENT ERASMUS+ project nr 2021-2-ES01-KA210-ADU-000048687, which is dedicated to economically active employees over 45 years of age and promotes integration in the labour market.

Keywords: inclusivity, DigComp, educationIT/ICT.

I. INTRODUCTION

Today's businesses as well as society as a whole are currently in the midst of a digital transformation that is affecting all types of business [1]. This process is conditioning companies globally - not just in terms of their internal operations or processes. Adapting to increasingly complex digital environments is a complex challenge for all companies and involves changing the way work is done, with significant implications for organisational behaviour, corporate culture, talent recruitment and leadership tactics [2], [3]. The potential benefits of digitisation are diverse and include increased sales or productivity, innovation in value creation, and new ways of interacting with customers [4], [5], [6]. Most digitisation strategies identify current and future operational activities, the required application systems and infrastructure, and the appropriate organisational and financial framework [7].

These elements can be attributed to four dimensions: technology use, changes in value creation, structural changes and financial aspects [8]. The potential benefits of digitalisation are manifold and include, among others, increased sales or productivity, innovation in value creation, and new ways of interacting with customers. Business models can therefore be reformed or replaced [9]. Without transformation of existing organisations, the economic and environmental challenges of the future cannot be sustainably met [10].

Digital competences have been recognised by the European Parliament as one of the eight key competences necessary for lifelong learning. They can be broadly defined as the competent, informed and creative use of ICT for work, learning, and active participation in society.

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Digital competences are specific as they directly contribute to and influence the acquisition of other key competences such as communication in the mother tongue and foreign languages, learning to learn, social and civic competences. They are linked to many of the skills that all citizens of 21st century Europe should possess in order to ensure their active participation in social and economic life.

The European Framework of Digital Competences for Citizens, known as DigComp, developed by the European Commission, is a tool for the development of digital competences of citizens. They present the characteristics of digital competences and group them into 5 thematic areas: Information and Data, Communication and Collaboration, Digital Content Creation, Security, Problem-Solving. In today's world, every digitally competent person must be fluent in these five areas

The purpose of Elene project [11] is to improve and expand the offer of high quality learning opportunities adapted to the needs of older people to improve their multilingual skills and digital skills. DigIN project aims to develop, test and implement an innovative digital education ecosystem to let educators create and share attractive learning activities for adults [12]. Talent Management seeks to develop training materials so that people over 45 years of age acquire the necessary skills that allow them to exploit their skills and competencies, thus strengthening their position in the working market [13].

These projects implemented by INBIE are strictly connected to digital transformation that is important for supporting the adaptation of one's business model. Transformation generates internal organisational resistance [14] and in order to cope with this resistance, transformational leadership skills are needed, which require the active involvement of the different actors affected by the transformation [15]. The aim of this article is to present mainly the activities carried out within the framework of TALENT MANAGEMENT project, which is dedicated to active workers over 45 years of age and promotes integration in the labour market.

II. THE ESSENCE OF TALENT MANAGEMENT

In 1998, a group of McKinsey consultants proposed the term 'war for talent' and noted that talent is the key to organisational excellence [16]. Since then, talent management has been seen as key to organisational success [17] and essential to the maintenance and sustainability of organisations [18]. Initially, the focus was mainly on educating and hiring candidates with above-average capabilities.

Creating an attractive workplace, i.e. an organisation that attracts potential talent, is done by creating, through public relations, an image of the company as an 'employer of choice'. The conditions for harmonious and targeted development must then be created through, for example, career planning, training, self-development, motivation or appraisal. No less of a problem is retaining talent within the organisation, as attractive offers from the external labour market are constantly waiting for them [19]. An important aspect in this area is the ability to manage the talents of employees over 45.

Senior talent refers to people with work experience and maturity who continue to work as they age. The participation of older people in the labour market has increased in recent decades, rising from 37% in 2008 to 42% in 2018 in the European Union. This is due to a combination of factors, such as improved health and life expectancy, the need to supplement pension and the search for new challenges and meaning in working life [20].

However, there are also barriers to older people's participation in the labour market. Age discrimination is one of the most common barriers, followed by a lack of training and development opportunities, and the perception that they are less productive and technologically obsolete [21].

III. TALENT MANAGEMENT IN SELECTED COUNTRIES

To overcome these obstacles and harness the potential of senior workers, many countries have adopted policies and programmes to encourage the active participation of older people in the labour market. According to a study by the Organisation for Economic Co-operation and Development [22], these initiatives include measures to improve training and reskilling, as well as to promote a more inclusive and diverse corporate culture.

It is difficult to pinpoint specific regions that have the best policies to promote senior talent, as this can vary depending on factors such as work culture, economics and pension systems. However, some countries have adopted effective policies to harness the potential of senior workers and improve their participation in the labour market.

Senior talent refers to people over 45 years of age who find it difficult to develop their professional life; sometimes due to the processes of digitalization and high technification of organizations.

In the context of the European project Talent Management, integrated by partners from Spain, Turkey and Poland, a study has been carried out to know the actions implemented by their companies in the field of Talent Management in people over 45 years old (Senior Talent Management).

For this purpose, a survey was designed and sent to Spanish, Turkish and Polish companies. Data has been collected from both CEOs and employees about people management policies and their perception, aimed at recruiting, developing and retaining talent. A representative sample of 122 people managers and 102 employees from the three participating countries was collected.

For the analysis of senior talent management in Spanish, Turkish and Polish companies, a representative sample of 122 heads of Talent Management was collected, of which 50.82% were women and 49.18% men. Of these, 50% were Spanish, 29.51% Turkish and 20.49% Polish. The Spanish respondents come from two of the most

economically important regions of the Spanish government: Aragon and the Valencian Community.

Organisations have strategically driven human resource activities to improve organisational performance [23]. Thus, management programmes that integrate HR activities related to recruitment and selection, extensive training and development, regular performance appraisal, contingent performance rewards and high levels of employee involvement [24].

The results obtained indicate that practically all the companies surveyed indicate that they carry out some type of Talent Management (TM) action in their organisation. Either following a strategic or an intuitive approach, regardless of the size of the company (fig 1).

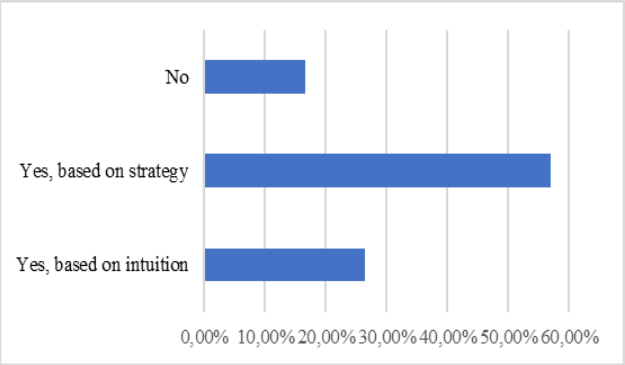

Fig. 1 Talent management activities.

The areas in which the company predominantly employs TMs are recruitment (32.79%), training and development (25.41%) and career management (25.41%) (fig 2).

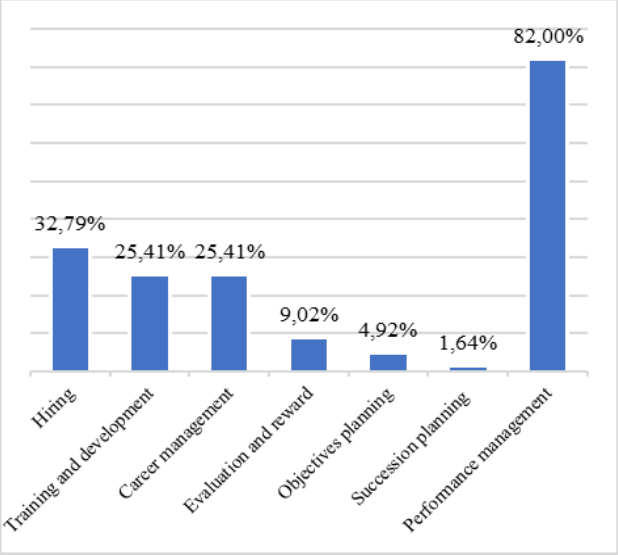

Fig. 1 Organisational areas in which TM is used.

The following are Talent Management performance maps of the managers of the companies consulted. Each of the maps represents variables with which the success or failure of Talent Management is identified. The maps graphically represent the average rating of each of the statements that make up the variables.

- Identification of critical positions.
- Talent acquisition.
- Talent development.
- Talent engagement.
- Talent retention.

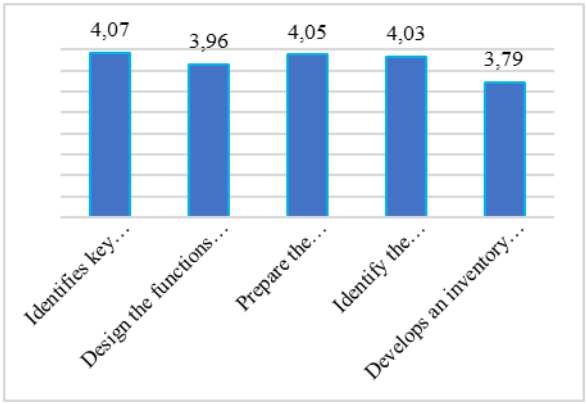

Fig. 3 Identification of critical positions.

With regard to the identification of critical positions by talent managers, we observe that companies score better in the task of identifying key positions according to the strategic lines defined by the organisation, while they perform less well in the task of drawing up the inventory of competencies required for these key positions.

The results also show gender differences. Men perceive the selection processes and the demands of the job to be more demanding. With regard to differences between countries, the results show that Polish women experience a greater monitoring of their training needs, especially in comparison to Turkish women.

IV. CONCLUSIONS

Research studies emphasise the importance of implementing people management systems, not only to improve production processes and productivity, but also employee satisfaction. Specifically, the results of this study show that in order to manage talent well, it is essential to identify those key positions in production processes and organizational development, with the aim of providing them with greater resources, so that people management is as optimal as possible. Above all, given the enormous difficulty companies have in selecting people for these types of positions. [25].

This points to the importance of adequate and consistent management of people, not only with the organisation's objectives, but also based on generating working environments that enable personal and professional development of employees.

In addition, due to the socio-geographical changes of recent decades, it is necessary for people management to take into account both the coexistence of different

generations and to pay attention to the different needs that each generation may have. Added to this is the increase in life expectancy and the consequent extension of working life, which will bring with it the need to take even greater care of the talents of senior citizens.

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Why T-shaped Engineers in the Mining Sector are Vital for Progress

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Abstract. **The importance of minerals and metals in the development of technologies vital for modern society to function and for increasing clean energy needs, cannot be understated. However, what is the level of knowledge of people working in this field, and how can we be sure that these people also update their knowledge continuously? There is a growing need for educated employees and engineers with a knowledge of wider issues associated with the mining sector. To align the competence of university graduates and employees with what is required in the labour market, it is necessary to develop a vocational system that identifies the competence of these mining-related occupations and incorporate new systems and ways of thinking, particularly in sustainability issues. Professional standards create opportunities for assessing competence. An occupational qualification standard describes the relevant occupational activity and competence necessary for practicing an occupation, i.e., skills, knowledge, and attitudes. When challenging work needs to be done, engineers with a deeper knowledge are needed, this is where the T-shaped professional comes in. The requirement for flexible and adaptable current and future employees is vital for the extractive sector and all the downstream industries that rely on raw materials to produce the goods and services that keep society moving. This article examines the importance of the T-shaped professional in the mining industry.**

Keywords: engineers, mining, T-shaped.

INTRODUCTION

What and who are T-shaped engineers? The concept of T-shaped skills was first introduced in the 1980s, but its importance to both individuals and organizations has continued to rise. T-shaped engineers are skilled in their core field but also have a good working knowledge of other related subjects. A T-shaped engineer has a particular specialization, but, at the same time, they are able to work with others in teams associated with their core responsibilities due to the fact they can speak and understand each other's working language.

Fig. 1. The visualisation of the T-shaped professional.

The letter T represents the combination of hard and soft skills that are an increasing requirement of many employers today. The vertical represents the core training of the individual. The horizontal is the ability to collaborate in other areas and apply knowledge in areas of expertise other than core competencies. From a mining perspective, the individual's core training or expertise is that of a mining professional, however, this, coupled with knowledge of mining impacts on biodiversity, local and wider communities, etc. can create a better environment for innovation, creativity and productivity. It can also contribute to the enhancement of the company's reputation within society and make it more attractive as an employer.

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METHODS

At universities, there are still ongoing questions on how to transform engineering education to better prepare students for future employers' needs [1]. In a rapidly changing world, graduate engineering students face increasingly complex problems and challenges upon entering the industry [2].

Climate change is the biggest challenge we face today. Europe aims to be the first climate-neutral continent in the world by the year 2050. However, this future relies on minerals and metals sourced responsibly and managed sustainably along the full value chain. In addition, mineral exploration and mining face significant challenges around establishing a social license to operate (SLO). If the mining engineer constantly improves their knowledge and are aware of the changes taking place, particularly in policies or legislation, then it builds greater empathy, trust and transparency when engaging with stakeholders.

A sustainable raw materials sector requires digital transformation, but there is much competition to attract suitable employees [3] [4]. Such a transformation acts as a natural connector among all segments of the raw materials value chain and can help to gain a more holistic understanding of processes and life cycles to boost efficiency and safety in exploration, mining and processing while reducing the environmental footprint and progressing more to a circular economy business model.

Definitely, a well-managed, motivated, and trained workforce has been a core driver for productivity and safety in mining [5]. Hiring and developing a diverse workforce is increasingly crucial for mining companies. Once a new engineer has been employed by a company, additional pain points may often include uninspiring capability development, below-standard occupational training, limited career progression pathways and insufficient inclusion. To lose talented employees due to such reasons is detrimental to performance and reputation.

Well-trained employees can be a true value driver for the company because their skills and knowledge can have a significant impact on a company's performance relatively quickly. Well trained T-shaped engineers may help deliver on the company's production targets and strategic objectives faster. There can also be an increase in de-siloing and a positive change in the working environment and company culture.

Fig. 2. New T-shaped engineers on site.

Upon examining the mining sector, we can see that there is a growing need for specialized and well-trained engineers. For example, over 90% of rare earth metals for clean technologies in Europe are imported from China. Swedish company LKAB is making a game-changing step towards Europe's resilience and resource security, becoming the main owner of REEtec, a young innovative rare earth separation company that based in Norway [6]. Europe is witnessing a disruptive transformation of the domestic raw materials sector, establishing a strong Nordic value chain and securing a sustainable supply of rare earth elements (REEs). But, it also needs to attract and retain the T-shaped talent to ensure a secure and sustainable supply of raw materials along the whole value chain.

Projects such as TIMREX, an EIT RawMaterials labelled Master's programme, initiated and funded by the EIT (European Institute of Innovation and Technology), a body of the European Union, is a step in providing the next generation of T-shaped professionals [7]. Graduates will have a strong entrepreneurial mindset and combine an in-depth knowledge of their own discipline with a sound understanding of the challenges appearing along the whole raw materials value chain. Complexity of the resources sector and mineral exploration work needs this mindset which is opened not only to other disciplines but also towards social and civic issues.

Tallin University of Technology (TalTech), is currently running the course CircPro for Masters [8]. The core idea of the course "Circular economy for Materials Processing" is to give an overview of raw materials processing, i.e from exploration, mining, processing, and manufacturing until material recycling and re-use thru the lens of resource efficiency and circular economy.

However, formal education credentials are not the only way to recognize a good engineer. Nowadays organizations should see lifelong learning as a core component in their employee's development, where employees can engage in training in order to be adaptable and flexible for the organization to stay competitive and relevant. Also, it increases the value and reputation of the company if they are offering the resources and training needed to foster their workforce.

Every company needs the best employees to achieve their goals, therefore lifelong learning plays an important role in an engineers' everyday work. Lifelong learning is a form of self-initiated education that is focused on personal development. Lifelong learning recognizes that not all of our learning comes from a classroom. Individuals must be encouraged and supported to develop their expertise and enhance their skills throughout their careers as part of their continuous professional development in the life-long learning process. New knowledge and skills development may include problem-solving, critical thinking, leadership, adaptability and much more that benefits the employee and the employer.

In today's economic situation, companies have to do everything to survive in highly competitive markets. Those who have qualified employees that have the skills and ability to increase the company's productivity remain competitive. Such a working environment increases the opportunities for innovation, entrepreneurship and intrapreneurship and skills and talent retention.

In Estonia (Fig. 3), there is a system of professional standards with 4 different type of Occupational Qualification for mining engineers [9]:

- Mining Technician, Level 5.
- Mining engineer, level 6.
- Diploma mining engineer, level 7.
- Chartered mining engineer, level 8.

The professional standards outline the skills and knowledge that an engineer has acquired. An occupational qualification standard is a document describing the relevant occupational activity and competence necessary for practicing an occupation, i.e., skills, knowledge, and attitudes necessary to work successfully. The skills can be soft skills (mainly cross-discipline expertise) and hard skills (skills that you need at your occupational level in the sector). Occupational Qualification is given out when the competence for the profession meets the competence requirements set out in the professional standards.

Fig. 3. Occupational Qualification for company employees.

CONCLUSIONS

The mining sector faces challenges on many fronts. Depleting ore grades, mining at greater depths, water, energy and waste management are just some of the operational challenges that are encountered by the industry. However, talent is increasingly being elevated from a simple enabler to a true value driver, but this talent is proving difficult to attain and retain within the sector. The competition for T-shaped professionals is intense and the mining sector is one of the least attractive industry out there. Nevertheless, the industry, in cooperation with academia, organisations such as EIT and regulatory bodies are investing resources now to ensure the sector can surmount such challenges for the future of society. If mining companies cannot keep supplying the raw materials in a more sustainable way due to lack of talented employees, then, every single one of us will be affected, as will future generations.

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Teaching English to Postgraduate Students in a Technical University Digital Environment

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Abstract. **One of the main tasks of training postgraduate students in graduate school is to develop competences necessary to present and discuss the results of their research work in a foreign language in oral and written forms, as well as to fully understand foreign language scientific texts in their specialty.**

In the last decades international scientific communication has shifted from a plural use of several languages to a clear dominance of English. The shift implies that an ever-increasing number of scientists whose mother tongue is not English have moved to English for publication and conference participation.

A literature analysis and own experience revealed such problems of postgraduate students' training in foreign languages as heterogeneity of the contingent with an unequal and often low initial level of language proficiency, a limited number of hours allocated for practical classes in English; a low level of self-directedness in language learning, a lack of elementary knowledge of the scientific discourse.

In an attempt to solve these problems, the Department of Foreign Languages staff at Kharkiv National Automobile and Highway University have developed and implemented a training course for postgraduate students in two, traditional paper and online, versions, the latter designed with the use of such a modern approach in language didactics as audiovisual translation appropriate for self-learning and flipped classroom activities. The course comprised three modules: scientific reading, academic speaking and academic writing. Besides, postgraduates with the elementary level of English were offered a grammar course covering all the basic grammatical topics necessary to formulate correct written and oral utterances.

The effects of teaching English with the use of videos with recorded parallel bilingual vocabulary and texts placed on an online platform were compared to the results of the traditional teaching with the use of the paper copy.

The research was carried out in the 2021-2022 academic year and aimed, firstly, to compare language skills of two groups of learners: those who studied the course with the use of audiovisual technology (the experimental group) with those who studied in the traditional mode (the control group); and, secondly, to reveal how the level of self-directedness changed in the process of the course study in both groups. The study involved a mixed approach of quantitative and qualitative methods to diagnose the level of learners' language competence and self-directedness. Our results indicate that the use of audiovisual translation in teaching foreign languages improves students' language skills and increases autonomy in studies.

It can be concluded that utilizing audiovisual translation due to auditory and visual support and opportunity for learners to study at their own pace has a significant impact on postgraduate students' language proficiency though this approach requires further research and wider implementation.

Keywords*: *audiovisual translation, learning English, postgraduate students, technical university.

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INTRODUCTION

The main form of training to receive a Doctor of Philosophy degree is postgraduate studies, by means of which postgraduate students can acquire broad knowledge of specialty, master the deep scientific and philosophical competencies, gain universal skills of a researcher. In addition, they must acquire the language competences necessary to present and discuss the results of their scientific work in a foreign language in oral and written forms, as well as to fully understand foreign-language scientific texts in the relevant specialty, as prescribed by government documents [1].

The intensification of the research work in Ukrainian universities has caused the need to restructure the work of teaching postgraduate students a foreign language, taking into account the fact that at present practically the only really demanded language of scientific communication is English.

Hamel claims that throughout the 20th century, international communication has shifted from a plural use of several languages to a clear pre-eminence of English, especially in the field of science with more than 75 % of the articles in the social sciences and humanities and well over 90 % in the natural sciences are written in English. The shift towards English implies that an increasing number of scientists whose mother tongue is not English have already moved to English for publication [2].

Since a modern researcher should be prepared to keep pace with the progress of science and technology, their education must cultivate their ability for intellectually active perception of what others have done in their field. To work successfully, specialists are expected to have complete up-to-date information about achievements in their field and have a deep knowledge of the relevant fundamental sciences, being able to use all this in practice.

The university should teach young people to use the entire arsenal of modern scientific methods to achieve the necessary results in a specific field, while easily adapting to changing conditions. This problem can be solved only on the basis of a strong fundamental foreign language education, which will provide access to information about the latest achievements in the field of the postgraduate student's specialization.

To conduct research, a postgraduate student must use foreign scientific publications in the specialty, which are almost always presented in English. It is also important for a researcher to participate in international conferences, where most of the reports are also presented in English. Writing abstracts in English is a requirement for all specialized journals almost everywhere.

Thus, the training of postgraduate students requires due attention to the issues of foreign language education and preparation for intercultural scientific communication in English.

The purpose of the article is to analyse the problems of foreign language training of postgraduate students in technical universities and to propose some solutions using innovative digital approaches.

The main goal of teaching foreign languages in graduate school is the development of the following skills: 1) to freely read foreign language scientific texts in the chosen specialty; 2) to translate authentic foreign language texts on a topic related to the field of scientific interests of a postgraduate student, skilfully using knowledge of terminology, grammatical structures, methods of translation transformations; 3) to process the information received from foreign sources in the form of translation, review, annotation; 4) to communicate in a foreign language in a professional and scientific environment (reports, presentations, round table discussions, participation in conferences, etc.); 5) to be able to provide written scientific communication on the topic of dissertation research (abstracts, theses, scientific articles, academic essays); 6) to effectively master the speech etiquette of scientific communication; 7) to perform logical operations (analysis, synthesis, argumentation, generalization, commenting and conclusions). No less important in the process of foreign language training of postgraduate students is the development of creative skills that help individuals to produce original ideas, apply a creative approach to solving problems [3].

However, in our opinion, one of the most important objectives of postgraduate students' training should be the development of the skills to acquire knowledge independently, since this is the main condition for their continuous development in future as scientists who keep up with the times.

An analysis of literature [4], [5] and own experience highlight the following major problems that complicate the process of learning a foreign language in graduate school: heterogeneity of the contingent, which has an unequal and often low initial level of language proficiency and different ages; the inconsistency of the high requirements for the level of language proficiency of future researchers and the small number of academic hours allocated for practical classes; a low level of development of postgraduate students' skills required for their self-directed learning; difficulties when working with a scientific text due to the lack of sufficient knowledge about its structural, stylistic and grammatical characteristics, ignorance of genre features of written types of discourse (abstract, annotation, review, article); insufficient mastery of methods of summarizing and paraphrasing information; difficulties in writing articles, theses, presenting research results; insufficiently developed listening skills; phonetic and spelling errors.

The experience of postgraduates' training at the Department of Foreign Languages at Kharkiv National Automobile and Highway University (KhNAHU) shows that in recent years, approximately 60% of applicants to graduate school have demonstrated skills at the level of

A1-A2 (elementary and pre-threshold), approximately one-third have had skills at level B1 (threshold), and a very insignificant part have revealed levels B1+ and B2 (upper-intermediate). Such a disparity in levels puts teachers in the face of a whole set of methodological difficulties: from which level to start training, which tools to choose, which would, on the one hand, meet the main demands of modernity, but on the other hand, take into account national specifics.

In this regard, such well-known manuals as "English for Scientists" [6] or "English for Academics" [7] cannot be accepted by domestic departments of foreign languages as a model, since they are designed for students who have already reached the threshold level and, in addition, they are designed for a significantly larger number of academic hours than Ukrainian educational standards provide for technical universities.

To solve the problems of postgraduate students' foreign language training, it was necessary to create a number of conditions that would ensure the effectiveness of training, namely: the choice of effective methods and technologies of training, the creation of a favourable psychological climate that contributes to the demonstration of personal abilities, increasing creative activity; creating a foundation for the implementation of an personalized adaptive model of learning; encouraging post-graduate students to self-education for improving their qualifications, promoting practical participation in international scientific contacts.

MATERIALS AND METHODS

In order to realize the above-mentioned conditions and provide mastering the means of scientific communication in a foreign language, the KhNAHU Department of Foreign Languages have developed and implemented a training course for postgraduate students, which was designed in two versions – the traditional paper edition "The manual in the English language for technical university postgraduate students" [8] and its online version, developed with the use of such a modern approach to teaching languages as audiovisual translation (AVT).

The main problem that arose while planning the course was how to prepare learners with different levels of knowledge for intercultural scientific and business communication for 48 academic hours, that were allocated for teaching a foreign language by the university's educational and scientific programs for postgradduate students of all specialties. It was decided to divide the course into three main modules – reading general scientific texts containing vocabulary characteristic of academic discourse, academic speaking (preparation for intercultural oral scientific communication) and academic writing (training in writing abstracts, articles, grant applications, summaries, preparation of a list of references, etc.). In addition, postgraduate students with elementary and pre-threshold levels were offered a grammar course covering all the basic grammatical topics necessary to construct correct written and oral utterances.

One of the prioritized components in foreign language training of postgraduate students is the mastery of scientific terminology related to their specialty. But, as the authors of the course claim, at the beginning of studies, authentic materials should have a popular science character, be understandable not only for postgraduate students as specialists in a certain field, but also for a foreign language teacher, who, as a rule, does not have additional technical education. And only after postgraduate students get used to easily operating general scientific vocabulary in receptive and productive activities, it is advisable that they move on to work with narrow-profile materials.

A separate section of the course deals with the preparation of future scientists for participation in international scientific conferences where English is used as the working language. Dialogues and exercises offer lexical conversational samples, the acquisition of which will help postgraduate students develop oral communication skills and overcome communication barriers with foreign colleagues. Postgraduate students learn to participate in any conversation or discussion of a scientific or academic nature, using idiomatic expressions and colloquialisms; study modern scientific literature in their specialty for the preparation of a dissertation research, which allows them to expand and deepen their professional competence.

The section "Academic writing" involves learning the Western manner of constructing an article based on the IMRAD model (Introduction – Methodology – Results – Discussion), writing abstracts, grant applications, drawing up a list of references according to various international standards.

The course offered an opportunity to master the most problematic and complex lexical-grammatical constructions. It was provided with videos for each topic, which were placed on an Internet platform [9], and listening to which allowed to practice the educational material at a time and place convenient for the postgraduate student. This enabled learners to independently master the language, which is the most modern trend in the world educational process and makes this course unique. The course also appeared useful when writing scientific articles and reports in English. Working with the course was supposed to contribute to the acquisition of integral, general and professional competences, which are necessary for the implementation of research and innovation activities.

Concerning the videos, they were developed using the audiovisual translation method. AVT as a modern trend in language teaching has a huge potential for learning a foreign language in personalized learning [10], [11]. In our approach, students were offered video and audio materials with parallel translation into the students' native language,

i.e. Ukrainian in our case; they were provided with a bilingual script, as well as recording of new words and texts in both languages for independent study. Thus, students saw the translated printed text, which provided them with the full semantic and pragmatic content of the statement in the shortest possible time. They repeated new words and phrases in pauses and then listened to the correct pronunciation. The postgraduate students were able to watch and listen to the videos as many times as they needed, at any time and in any place convenient for them.

In the classroom, the teacher used already learned material in new contexts, varying it with the help of substitutions, transformations, extensions and new combinations. For self-study, the course was provided with self-tests.

During the course implementation another modern approach – the flipped classroom technology – was used.

The idea of this technology is that the main stages of the teaching and learning process, such as classroom activities and homework, change places. It means that the theoretical material is studied by students on their own by watching videos and listening to audio lectures recorded by the teacher, or preformed materials downloaded from websites on the Internet, while in the classroom the students are involved in fulfilling practical tasks and discussion of problematic issues [12].

After careful working out the course material, the postgraduate students were prepared for independent scientific activity in a foreign language related to their specialty. They necessarily took part in a scientific conference organized by the Department of Foreign Languages with the invitation of specialists from other departments and postgraduate students from other universities and the publication of an article on the topic of their dissertation research in the annual collection of student scientific papers, "Studentship. Science. Foreign Language" which is published by KhNAHU.

Participation in the conference enabled the postgraduate students to demonstrate their skills and ability to communicate in a foreign language, to express themselves productively on professional and scientific topics, to effectively present the results of the conducted research (description of graphs, tables, diagrams, schemes; the use of appropriate terminology), to take part in discussions.

In the process of learning a foreign language of a scientific direction, special attention was paid to the peer-to-peer method. We offered postgraduate students to give a lecture or conduct a training on the topic of their research in a foreign language to Master's students of the same specialty during a foreign language class. If postgraduate students took an internship, they could prepare a presentation in order to acquaint Master's students with the experience of conducting similar training in other educational institutions, etc.

RESULTS AND DISCUSSION

This study aimed to investigate the effectiveness of the AVT technology when implemented for the postgraduate English learning course. The research questions were as follows: 1. What were the learners' achievements after the study of the course with the use of AVT technology? 2. How did the level of self-directedness change in the process of the course study?

Using the method of randomization, an experimental group (EG) of 32 people and a control group (CG) of 33 people were gathered. The EG postgraduate students studied a foreign (English) language course during the 2021-2022 academic year with the use of the AVT approach while the CG postgraduate students used the traditional paper version of the course.

The students attended twenty-four 90-minute class periods during the academic year with a big emphasis on the independent out of class work. The EG postgraduate students were expected to watch and listen to the videos designed with the AVT approach. The CG postgraduate students used only the paper version of the course.

The mixed-methods design was used to explore the learners' achievements with and without the AVT approach and their self-directedness in language learning. The independent variable was the classes which included the English postgraduate course content. The dependent variables included the learners' achievements and their self-directedness in English learning. The first dependent variable was measured by comparing the pre-test and post-test results. The second dependent variable was measured using the questionnaire and informal group interviews.

The performance test was used to evaluate the learners' proficiency regarding various language skills in academic speaking, reading and writing before and after studying the course.

The test consisted of one hundred test items including multiple-choice questions, true/false questions, cloze tests, "odd one out" items, matching items, transformation items, listening and speaking test items, etc. The total score for the performance test was 100 points.

Then, the number of correct answers for each student was calculated, and the level of language proficiency was determined. If the number of correct answers was more than 80%, the level was assessed as high, 60–80% – as sufficient, and less than 60% – as elementary. The dynamics of the change in the number of students with different levels of language skills is presented in Fig. 1.

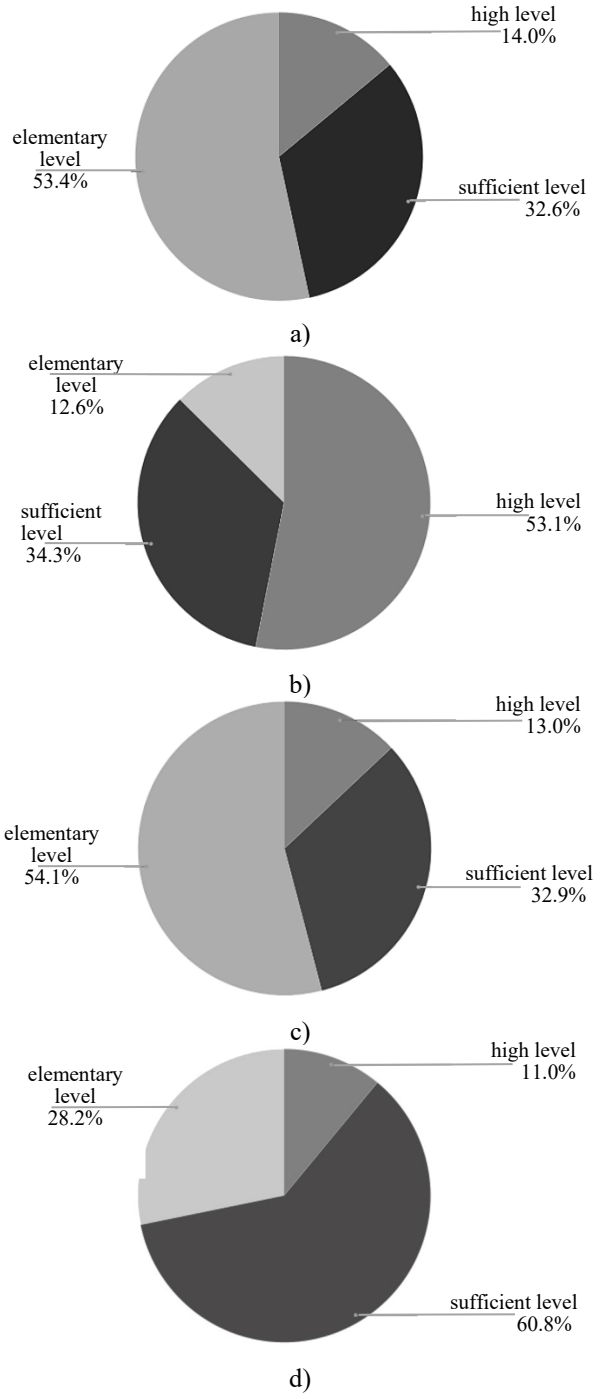

Fig. 1. Changes in the number of students with different levels of language skills: a – experimental group (ascertaining data); b – experimental group (control data); c – control group (ascertaining data); d – control group (control data)

These data confirm that the proposed approach contributed to the improvement in the postgraduate students' skills in reading, speaking, listening, and writing in the area of the academic and scientific discourse.

To receive the indicator of self-directedness the postgraduate students were asked to answer the following items of the questionnaire (Table 1) with the rank ordering from 1 to 10 developed by [13] though adapted to our purposes:

TABLE 1 LIST OF ITEMS

No.	Item
1	I can see the benefits for my work and/or personal development from completing the course.
2	I monitor how much I have achieved in terms of learning at each stage of a course.
3	I know what I want to achieve in terms of learning from the course.
4	I am at a loss as to what I should be learning over the duration of a course.
5	I find time to study the learning materials in a course.
6	I do not know what I'm supposed to be doing whenever I sit down to study.
7	I feel that I have too much to accomplish in terms of learning towards the end of each course.
8	I do not submit my assignments on time.
9	I plan what I need to learn in a course.
10	I keep postponing my study tasks designated in a course.
11	I prefer to do other things than study the learning materials of the course.
12	I find excuses for not studying for courses.
13	I follow my study schedule.
14	I cannot focus during online presentations and practical classes.
15	I relate the content of the learning materials or resources to my work or life.
16	I do well on my assignments.
17	I love attending practical classes.
18	I am physically drained when I am studying.
19	I feel motivated whenever I am studying.
20	I am demoralised when I do not meet the expectations I set for myself in my studies.
21	I do not worry about not submitting my assignment on time.
22	I do not understand what is required of me when tackling the questions in tests.
23	I feel confident when taking tests.
24	I am very comfortable using a computer.
25	The internet provides me with a wealth of resources for my assignments.

The questionnaire was completed via an online survey tool. The online tool enabled the participants to enter their inputs directly into the system that allowed to collect and generate data swiftly.

Points scored by each student were summed up and the arithmetic mean for one student in the group was determined by the formula:

$$X = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (1)$$

n is the number of students in the group; x_i is points of the *i-th* student.

Changes in the character of self-directedness were evaluated according to the Stoeffer's ratio, which can be presented as $D = X_2 – X_1$, where D is the result of the change, X_1 is the average point before the experiment; X_2 is the average point after the investigation. Thus, for the experimental group, the average point X_1 before the experiment was 33.6, and after the experiment X_2 =76.7, which means that D = 43.1. In turn, for the control group, X_1 was 31.3, and X_2 was 44.5, and, accordingly, the value D was 13.2. The difference of values D in both groups strongly supports the effectiveness of the proposed approach.

Williamson [14] stated that those with a moderate level of self-directedness are already halfway from becoming self-directed learners. However, they need to recognize and evaluate a few areas for improvement, and some strategies might need to be adopted together with a teacher's guidance if necessary. Those with a high level of self-directedness may need to maintain their progress by finding effective and suitable methods to strengthen their self-directed learning.

Self-directed learning does not mean it is all up to you; rather it is a collaborative approach to identifying the learner's strengths and weaknesses with respect to the programs outcomes and then working constructively on building strengths and developing capacity in areas of weakness.

As to the flipped classroom approach, it can be considered pedagogically sound because it provides personalized-differentiated learning and student-centered instruction though it has both pros and cons. Among the pros the following can be pointed out: learning at one's own pace, advance student preparation, overcoming the limitations of class time, increasing the participation in the classroom. Among the cons are the possible students' lack of equipment and unlimited access to the Internet resources; there is also no way to guarantee students will adapt to the flipped model immediately while the technology completely relies on their diligent work on their own.

The approach means an extra workload on teachers who have to develop, record and upload lectures, which take time and skill, as well as carefully integrate newly developed resources into the classroom work. Although once designed, videos can be used an unlimited number of times in the future, which will provide teachers with significant convenience.

In general, the technology of blended learning which assumes the combination of e-learning and classroom activities leads to a new format of the educational course, a change in the type of communication and interaction between the teacher and the postgraduate students, and the organization of the postgraduate students' independent cognitive activities.

CONCLUSIONS

The training of postgraduate students in technical universities of Ukraine involves not only the defense of the thesis in a certain field of research, but also the further development of foreign language scientific and professional communicative competence, which has a positive effect on the development of a personality capable of continuous professional self-development. The priority is given to training in English, which has firmly taken the first position in the field of cross-cultural scientific communication.

The effectiveness of foreign language training of postgraduate students depends to a large extent on the use of the latest methods and technologies of learning and effectively organized independent work.

The main advantages of blended learning using such a modern approach to language teaching as audiovisual translation are the openness and flexibility of the educational process, greater independence of postgraduate students from the place and time of classes, an individual mode of educational activity (the ability to individually choose the pace, rhythm and volume of educational material), the possibility to get quick feedback. The use of this approach has led to a significant improvement in language skills in scientific and professional communication and the consolidation of self-directedness in a foreign language study.

There are some suggestions for future research which have not been discussed in the present study.

The rapid development of information and communication technology has a great impact on language testing and assessment. In terms of practicality and test administration, online tests appear to be more practically administered as they save time of both, teachers and test takers. So, attempts should be made to propose a design of an online achievement test specifically devised for postgraduate students as nowadays many teachers prefer the online test to the paper-based test due to its efficiency.

In general, learner-centered e-learning technologies related to the formation of an active personality capable of independently organizing their professional and educational activities for continuous professional improvement require further development.

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DIGSM 4.0 Curriculum Lifecycle Based on Component Organised Learning Method

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***Abstract*. The research under consideration is how to build COL (Component Organised Learning) based curriculum lifecycle that teachers can apply in different fields. The problem is that the degree studies curriculum is not always applied to working students as the needs of the companies they work for differ. Companies find it more valuable when students can use the existing curriculum topics to solve today's company problems. Current degree studies take considerable time and are unsuitable for full-time employed specialists. The proposed Education 4.0 concept brings the knowledge and skills required by the market for full-time employed students in a time-efficient way. One possible solution to apply this concept in practice is to create a micro-credential curriculum for companies. The authors suggest using the intensive week approach for analysis, where the students will solve the real company problem using previously studied solutions. They will also use the Moodle courses linked to the developed COL to speed up access to the materials. Authors suggest organising such an event in collaboration with consortium partners and involving all teaching staff who worked on course development. After introducing problems brought by the company and visiting the company on site, asking the questions, students define the task to be solved in groups. After that, the Authors recommend providing intensive courses where each partner will present the developed Moodle materials. The target is that the students will solve the problem in 24h and present solutions to the company representative.**

Keywords: Component Organised Learning (COL), digitalization, Digital Supply Chain, Information and Communication Technologies (ICT), Higher Educational Institutions (HEI).

I. INTRODUCTION

Short-time learning or learning via short courses has become more popular. Higher Educational Institutions (HEI) need to rebuild their curriculums to enable combining work experiences with short-time classes. Current degree studies take considerable time and are unsuitable for full-time employed specialists. The proposed Education 4.0 concept brings the knowledge and skills required by the market for full-time employed students in a time-efficient way. One possible solution to apply this concept in practice is to create a micro-credential curriculum for companies.

A well-structured e-environment for studying is the only way for this. They are building an engaging, time- and skill-consuming curriculum for educators. The authors aim to solve the problem of how to apply COL (component organised learning) modules to full fill students' and enterprises' needs. The challenges to be solved include constructing the education 4.0 concept, shortening the time of bringing enterprise needs to the curriculum and validating the named idea.

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The concept will help students learn study programs in the certificated organisation in a short time and work simultaneously. It will give students a way to learn further in the future when needed as the study program is transformable to another organisation. At the same time, students learn how to find solutions for the company where they work. For enterprises, it will allow sending students to learn the topics needed to solve problems in specific companies. In the future, the concept could be used in advance for all the enterprises in the same field to select topics required to learn. Those topics could be updated and used in one platform.

Current research aims to align the curriculums to fulfil the needs of the companies on their journey to the digitalisation of Supply Chains. The paper will be focused on the following research questions.

- How to assess dynamically and efficiently the digitalisation needs of companies?
- How to create and deliver the required digitalisation knowledge by creating the courses?
- How to validate courses that they full fill all participant's needs?

The Digital Supply Chain Management 4.0 (DIGSCM 4.0) project supports this research. The developed framework is constantly improved by partner organisations from TTK University of Applied Sciences (TTK UAS, Estonia), Rezekne Academy of Technology (RTA, Latvia), and Vytautas Magnus University (VDU, Lithuania). The project's goals are to build the DIGSCM module, which consists of 15 courses targeted to cover the digitalisation needs of the companies. The project is limited to Purchase and Procurement, Logistics and Manufacturing. The authors focus on digitalisation's effects in a supply-chain context.

Today our research group have completed the execution and international validation of 5 courses. Teachers and students have received valuable experience before we further deliver the subsequent ten courses. Implementation of courses took place during the academic year of 2021/2022, and the research group is interested in sharing the current results. We improved the framework suggested in the previous paper [1] by introducing the Component Organized Learning (COL) matrix, which enables us to connect the assessment of skills, technologies, and impact of digitalisation provided by companies from the Procurement, Manufacturing and Logistics sectors. Companies share with universities the current expectations, and universities review and deliver those expectations through DIGSM 4.0 module courses. The target is to enable a dynamic teaching environment and reduce the delivery time of skills to the market by adjusting the courses by using the COL approach, delivery of this knowledge to the contributed companies at the end of the semester by preparing the students for the company annual internships, the readiness of students to contribute to problems solving in final theses and final providing the skilled alumni for businesses.

II. LITERATURE REVIEW

This literature review will present novel perspectives and topics under investigation. The literature review will give an overview of how workforce learning is done at the moment and how curriculum review is changed during the timeframe. Added is what are their limitations and future perspectives. As our work is directed at using micro degrees and learning while working, we will focus on those topics mainly. Although the provided solution is applied in the eLearning environment, its flaws will also be essential to consider. For instance, students could need eLearning challenges for more self-regulated learning and using technology [2]. Challenges could also be lectures' reluctance to deliver content using technology [3]. This problem is decreasing as massive use during the COVID-19.

Learning could happen around the world, and topics are repetitive. To hold reusability higher, the concept of RLO is proposed in literature before [4], [5], [6]. The name and concept are different from those used before RLO (Reusable Learning Objects) [7]. All named research was focused on what criteria and qualities reusable learning objects should have but not used in the context of timeshare between parts of the thing. Our solution takes a view of the internal structure of an object.

There is a way to share learning objects between stakeholders using a digital platform. Integrated E-Learning Objects Design Model and Implementation into Educational Platforms help reduce the time developing instructions and help share knowledge between universities [8]. The weakness of reusable learning instructions is that they could be outdated [9]. Platforms could be underusage as enterprises won't use educational organisation platforms and sheer them between enterprises.

The Industrial Revolution 4.0 brought with it the introduction of new teaching methods. New opportunities have brought people and technology together and created a more flexible environment for learning and studying programs adaptable to enterprises' needs. Peter Fisk defined the main trends related to Education 4.0 [10] as learning can be taken anytime, anywhere. The more personalised practices, the possibility to choose the way You learn, more hands-on learning, applying theoretical knowledge to practical case solving, and considering students' feedback. The research states that the need for learning topics and content should be driven by market force [11]. At the same time, much research has stated that conventional curricula lack the requirements of what the modern job market needs [12], [13], [14]. The importance of changing the curriculum accordingly to the need of today's workforce is also mentioned [15]. Still, this research is losing the timeframe between curriculum redesign and delivered curriculum. In today's world, it is essential to have shortened time cycle for learning as students work.

In [16], curriculum redesign is prolonged and resource-consuming activity. Thus, it is essential to have initiatives that reduce resource consumption in the design curriculum.

III. COMPONENT ORGANISED LEARNING CONCEPT

Authors have reused the previously discussed trends to develop a new learning approach - Component Organised Learning (COL), which uses interactive practical assignments [1]. COL has a common structure that RLO (Reusable Learning Object) lacks and gives a more standardised body to objects, and allows analysing and studying the concept's good sides and flaws. Our solution provides an opportunity to revise the COL annually by analysing answers from companies and changing the content. Advantages COL for students are introduced in Fig.1.

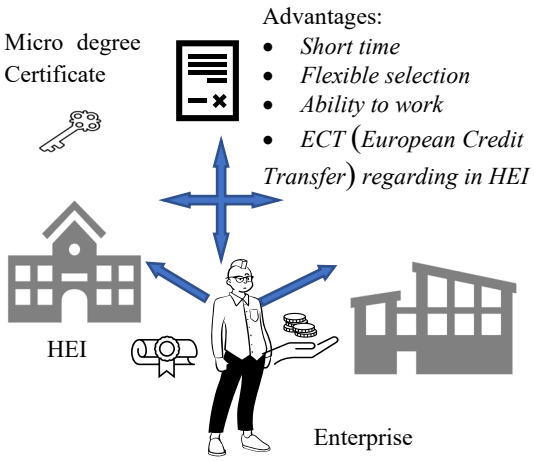

Fig. 1. Student choce.

How it works is shown in the Fig. 2.

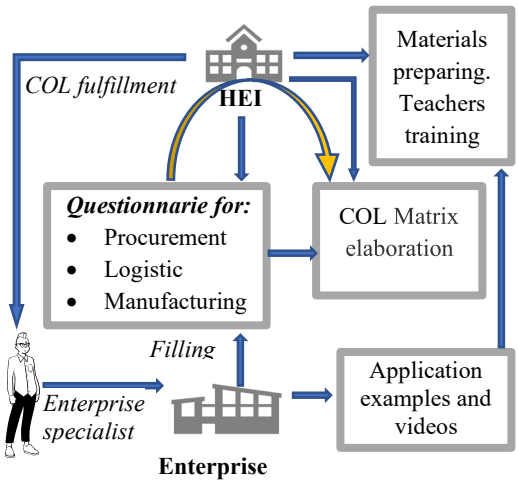

Fig. 2. COL implementation.

Component Organised Learning (COL) is a concept, suggested by authors to divide the course into small cells corresponding specified duration of the learning task [1, 17]. Potential users of the framework would be logistics and management and administration teachers, companies, and students. Once the COL is created and connected to related study outcomes, it can be successfully reused in different e-learning courses to support content flexibility and course connectivity. COL enables the interconnection between different curriculums, which provides a broader view of the value chain essential for students to become better specialists. It also supports the flexibility and optimal use of teaching staff, with the possibility of simultaneous teaching of COL related to different courses and curriculums. In the current research, the authors develop a COL matrix, which defines the relationships between required knowledge, technologies and implementation impact provided by the study outputs of the courses.

The lecturer prepares a questionnaire and introduces it to partner companies interested in university students to design the study block. The questionnaire will enable dynamic adjustment of curriculums towards the expectations of companies in the digitalisation field.

Using the questionnaire, the lecturer assesses the competencies, technologies, expected impact, and challenges companies request, analyses and generates the study outputs into the existing curricula courses. Then, in cooperation with the partner universities, additional study blocks are developed to cover the necessary competencies. The completed modules are offered to students within the existing subjects or electives, focusing on developing critical thinking and reflection skills. After implementing the curriculum, the teacher asked students to fill in a questionnaire to validate the delivery process of the requested skills. [18-20].

A. COL structure

The idea of COL structure, see Fig 3. is suggested by partner universities. Today we combine the video-recorded lecture and practical part performed in selected ICT (Information and Communication Technologies) tools and discuss the sharing of teaching load between HEI-s. Using the ICT tools via hybrid learning and e-learning gives more possibilities for communicative learning for teams with members in different locations.

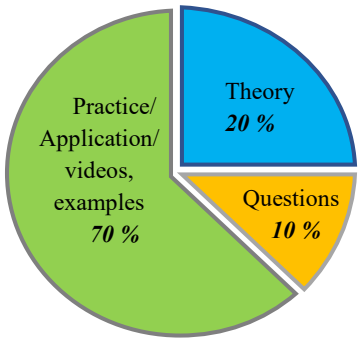

Fig. 3. COL structure.

B. COLs defined on base of questionnaires

The authors have developed and spread the questionnaires to the Baltic States companies in Logistics, Manufacturing and Procurement fields and suggest selecting COL from the list based on previously defined parameters, see Table 1. The definition of technologies aims to support mapping skills required by companies with particular learning content.

TABLE 1 COL NAMES WITH SIMPLIFIED DEFINITIONS

COL	Definition
1. AI	The ability to teach the algorithm based on validated data
2. BIG DATA	Ability to create new knowledge based on a significant amount of data
3. IOT/ Blockchain	Ability to extract the data from devices / secure the operational data
4. BPM	Business Process Mapping software
5. SMART SENSOR	Know-how and skills for the usage of radio frequency identification and smart sensors in tracing of supply chain processes
6. Cyber Security	Cyber security tools and policies
7. Predictive Analytics	Predictive software, forecasting algorithms
8. ERP	Enterprise resource planning
9. Innovation	Ability to create new solutions, previously not used in current context
10.Communication	Communication software, Social Network software, messengers, skype, etc.
11. Robotisation	Able to replace the manual activities by using robot or RPA solution
12. Lean and Agile	Lean and Agile tools and software
13. Risk Management	Ability to estimate the non-fulfilment of strategic targets
14. Cloud	Software working in the Cloud environment
15. SCOR	Supply Chain Operation Reference model-based
16. Integration	Integration between different Information Systems
17. API	API interfaces for data exchange
18. Simulation	Simulation software (processes, games)

The next chapter shows how this list was developed on the Digital Supply Chain Management 4.0 project example.

IV. DIGSCM 4.0 PROJECT

The project's goals are to build the DIGSCM module, which consists of 15 courses targeted to cover the digitalisation needs of the companies. The project is limited to Purchase and Procurement, Logistics and Manufacturing. The authors focus on digitalisation's effects in a supply-chain context.

Curriculum development based on the questionnaire for enterprises enables dynamic adjustment of learning programs towards the expectations of companies. Authors have developed questionnaires for the Baltic States' companies to get their knowledge, impact, challenges and technologies preferences. Primary statistical information about respondents is introduced in Table 2.

TABLE 2 STATISTIC INFORMATION ABOUT RESPONDENTS

Country	Logistics	Manufacturing	Procure-ment	Total companies
Lithuania (*LT)*	15	27	10	52
Latvia (*LV)*	3	11	4	16
Estonia (EE)	7	5	4	16

HEIs map the required knowledge of the companies to a particular topic in the suitable course, select the expected impact and related technologies from the questionnaire, and add them to the matrix. The impact will show how the delivered digitalisation knowledge will support the companies in achieving business targets.

Calculation of the weight of questions based on questionnaire data.

> *Questions weight = (Estonian companies assessment % + Latvian companies assessment % + Lithuanian companies assessment %) /3 /100.*

Calculation of the priority of COL based on weight as:

> *Priority=points of Knowledge required* X *points of impact of digitalisation* X *points of tool importance.*

The size of the COL will be periodically readjusted at the beginning of the academic year to better correspond to the updated needs of the company. The advanced teaching method will also be applied for existing re-educating employees by providing micro degree programs. The student selects the courses aligned with the current employer's strategic directions and plans in Supply Chain Digitalisation.

The size of a particular topic in the course will depend on question weight; for example, the topics that received higher priority will have a more significant amount in ECTS in each course. The advantage of the method is that it increases the motivation of students, partner companies, and teachers by joining contributions and fulfilling requirements.

For example, Table 3 introduces a priority index definition matrix for COL 4, COL 14, and COL18.

TABLE 3. MATRIX FOR COL PRIORITY INDEX DEFINITION

COL	Knowledge required	question weight	Impact of digitalisation	question weight	Tool importance	question weight	Priority index
14. CLOUD COL	Know-how and skills of the usage of procurement platforms based on "many-to-many" communication.	0,76	Transparency and traceability within the supply chain ecosystem will strengthen buyer-supplier relationships	0,5	Procurement platforms based on "many-to-many" communication will simplify my daily business	0,8	0,3
18.Simulation COL	A common user interface (for platforms and applications) will enable me to work more efficient and effective	0,76	Transparency and traceability within the supply chain ecosystem will strengthen buyer-supplier relationships	0,5	Abilities to use common user interface platforms and applications in executing supply chain operations.	0,73	0,3
4. BPM COL	Know-how and skills of the usage of procurement platforms based on "many-to-many" communication.	0,7	Procurement function will be a strategic interface to support organisational efficiency, effectiveness, and profitability	0,66	Procurement platforms based on "many-to-many" communication will simplify my daily business	0,8	0,4

TABLE 4. DSCM COURSES

	DSCM Courses	Planned Course	ECTS
Procurement	Course 1	Purchasing and Procurement Management	3
	Course 2	The organisation of the digital purchase process	3
	Course 3	Introduction to Public Procurement Planning and Procedure	3
	Course 4	Project. Purchasing and procurement organisation	3
	Course 5	Project. Analysis of the procurement process	3
Manufacturing	Course 6	Introduction to Supply Chain digitalisation	3
	Course 7	Intelligent Manufacturing and Industry 4.0 tools	3
	Course 8	Transformative technologies	3
	Course 9	Digital Twin for Manufacturing Environment	3
	Course 10	Manufacturing Process Management in Supply Chain	3
Logistics	Course 11	Logistics 4.0 and Business Process Reengineering	3
	Course 12	ICT in Logistics	3
	Course 13	Transformative technologies	3
	Course 14	Digital Twin for Logistics Environment	3
	Course 15	Logistics Process Management in Supply Chain	3

Based on the priority index was developed 15 courses and defined for them ECTS (European Credit Transfer and Accumulation System) in Procurement, Logistics and Manufacturing areas for Digital Supply Chain Management (see Table 4).

Courses can use one or more COLs. Table 5 shows COL 4, COL 14, and COL18 used in several classes.

TABLE 5. COLS USED IN SEVERAL COURSES

Courses	COL 14	COL 18	COL 4
Course 1	X	X	
Course 6	X	X	X
Course 10		X	
Course 15		X	

V. RESULTS AND DISCUSSION

In the current paper, we introduced the integration of several courses between different HEI-s. At the current stage of the project, the following courses are built/redesigned accordingly to the need of the companies. The new learning methods need to enhance the e-teaching the technical-digital skills combinations. For the best outcome, the data collected from companies via questionnaire defined the competencies, the impact of digitalisation and ICT skills the companies see as the most relevant in supporting their further goals. The introduced approach by mapping created course study outputs with corresponding COL-s and calculating the priority index to define the size of the COL-s. In addition, students' feedback improves the development of the lowing ten courses in the projects.

International teaching experience for TTK, RTA and VDU students and teachers highlighted several challenges to be solved. They applied real-time teaching environments and worked on infrastructure preparation for common near-

life project preparation. The data collected will be described in the ERP system to be fulfilled by the different roles of HEI partners. TTK UAS students will be responsible for Procurement and purchasing components, RTA students will perform the manufacturing activities, and VDU students will perform logistics for materials and finished items. Training in conditions near real life, like using different software solutions, gamification and simulations and enabling students to participate via remote solutions can be one way. Guiding and assessing students' tasks remotely need to develop, considering the student's expectations and employers' needs.

COL question weights may change with the re-study of future employer needs, which will change the priority and the size of corresponding topics in particular courses for the next study period. The designed courses content was adjusted based on company requirements, and the authors plan to use the COL matrix to design the following courses.

VI. CONCLUSIONS

The research paper's authors have developed a framework for dynamic curriculum improvement supported by the DIGSCM 4.0 Erasmus+ project. The project's target is to periodically update the curriculums based on business requirements at the beginning of each study year.

This work authors have designed the questionnaire to evaluate dynamically and efficiently the digitalisation needs of companies. A study of the needs analysis of the business sector was carried out. It helped to highlight the need for the knowledge, competencies and skills of trained specialists in the fields of trade, production and logistics in the 4-industry revolution. During the research, the authors carried out the analyses of competencies, abilities and knowledge needs at the international level and adapted the portfolio of study subjects so that the trained specialist would be suitable not only for companies operating at the national but also at the international level was observed.

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Architecture and Construction Students' Perception of "Technical Drawing" and "Descriptive Geometry" Discipline Content

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Abstract. **The present paper highlights the results of pedagogical research conducted at the Architectural Department in the Kamianets-Podilskyi Professional College of Construction, Architecture and Design. The study considers the vocational pre-higher education students' perceptions of various graphic works in drawing and descriptive geometry in the context of graphic work features, and understanding the significance of drawing works for the formation of a future specialist in the construction industry. Students were suggested to fill in the forms with a list of the curriculum topics and give grades according to three criteria: usefulness for the future profession, the complexity of the graphic work and the engagement in performing the task.**
Research results provide problem-solving solutions related to teaching methodology of such disciplines as "Technical Drawings", "Drawings and Basics of Descriptive Geometry" and "Descriptive geometry".
Based on research findings, the recommendations concerning teaching and increasing interest in educational material can be made. It has been found that certain topics do not arouse much interest in students, so we recommend improving students' motivation in the classroom by employing engaging tasks, taking into account the peculiarities of perception and attention when studying these topics. The topics that are difficult to master according to students' responses require more hours for studying, and the topics that students consider least useful should be reviewed, reformatted, or even excluded from the program.

Keywords: technical drawing, descriptive geometry, graphic work, perception of the material, interest in work, complexity of performing, usefulness for the profession.

I. INTRODUCTION

Improving the content of education is a priority task for the state. In this regard, it is necessary to improve curricula and training plans; provide innovative teaching methods and materials; substantiate modern criteria for evaluating the effectiveness of the educational process.

An important component in future construction specialities' training is the development of students' graphic skills and abilities. That is why their professional training should include activities for acquiring well-formed graphic knowledge and skills to develop a high level of graphic culture.

The standard of higher education indicates such special (professional) competencies as SC06 and SC09. The first competence, for example, includes the ability to perform technical and artistic images for use in architectural, urban

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planning, design and landscape design. The second competence (SC09) suggests developing architectural, artistic, functional, volumetric-planning and design solutions, as well as carrying out technical drawings, and preparing documentation for architectural projects [1]. These competencies are implemented during the study of disciplines related to graphic literacy and the creation of images carried out in the form of drawings or blueprints. Therefore, the subjects of the research are the disciplines related to teaching technical drawing to students. Such disciplines as "Technical Drawing", "Drawing and Descriptive Geometry", "Drawing and Perspective", "Engineering Graphics", and "Architectural Graphics" are taught to students of different specialities.

Studies have shown that disciplines related to drawing are the only disciplines that develop the spatial vision. They are the basics of jobs such as architect, builder, designer, engineer and many others. In addition, teachers of Natural and Mathematical Sciences note that when students are familiar with drawing, they have no difficulties in mastering science-related disciplines [2].

It should be mentioned that teaching "Technical Drawing", "Drawing and Descriptive Geometry", "Drawing and Perspective", "Engineering Graphics", and "Architectural Graphics" has peculiarities for each speciality, so the content of various alternative programs will differ significantly. The units and topics related to the basics of Drawing and Descriptive Geometry can be considered the least variable component. It is here that the common features of mastering drawing graphics are concentrated, so the topics from this cycle slightly differ for both construction and non-construction specialities. However, this does not mean that all topics have the same content importance and significance for students of different majors.

V.M. Burynskyi, O.M. Dzhedzhula, M.M. Koziar, V.V. Moshtuk, V.Y. Naumenko, H.O. Raikovska, V.K. Sydorenko, D.O. Thorzhevskyi, V.I. Chepok, A.P. Verkhola, Z.M. Shapoval, N.P. Shchetina, M.F. Yusupova and several other researchers actively worked on various issues of teaching drawing in Ukraine [3-11]. However, there is no previous research on scientifically based and student-centred approaches to the structure of the training course in Drawing [12-18].

The purpose of the present study is to explore the perception of topics from the Drawing and Descriptive Geometry course by students majoring in "Architectural Design and Interior" (architecture), and "Decoration of Buildings and Structures and Building Design" (design). To achieve this goal it is necessary to solve the following tasks:

- highlight the most specific and commonly used topics in the Drawing and Descriptive Geometry course and identify appropriate graphic works;
- design a questionnaire survey to obtain students' opinions;
- conduct a survey;
- analyze the results and make conclusions.

II. Materials and Methods

The research was conducted at the Architectural Department of Kamianets-Podilskyi Professional College of Construction, Architecture and Design in the 2018/19, 2019/20 and 2020/21 academic years. Two groups of second-year students (D-21 (Designers) and A-21 (Architects)) participated in the experiment. The discipline "Drawing and Perspective" was taught to the students of the first group, and the discipline "Drawings and Descriptive Geometry" was taught to the students of the second group. The survey included topics that were commonly used for all specialities. The topics relating to the construction drawings of houses and their elements, the setting of shadows, as well as the construction of perspectives, were not taken into account. After studying the relevant topics and performing graphic works, the respondents were suggested to assess the significance of a particular work in terms of:

a) The complexity of the construction,
b) The engagement in performing the task,
c) Usefulness of the skills acquired during the performance for the future profession.

The respondents were suggested to evaluate graphic works common to all specialities:

1. Drawing fonts.
2. Drawing lines.
3. Conjugation.
4. Projections of a point and a straight line.
5. Plane. Plane conversion.
6. Axonometric images.
7. Group of geometric bodies.
8. Cut geometric figure (pyramid, cone).
9. The intersection of geometric bodies.
10. Complex drawing of a volumetric model.
11. Simple cuts.

The students were given forms with a list of these topics, miniature images of graphic works and three columns for grading according to the three above criteria (Fig. 1). The assessment was conducted according to a 10-point system, where 0 is the minimum impact and 10 is the maximum impact on the criterion.

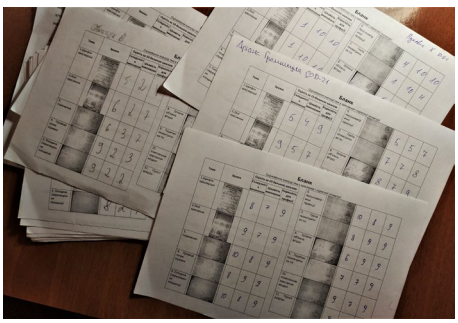
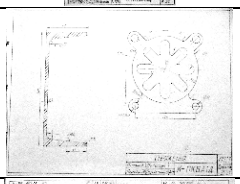
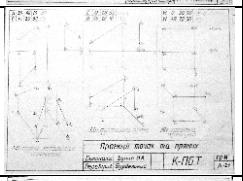
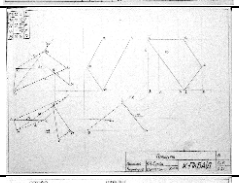
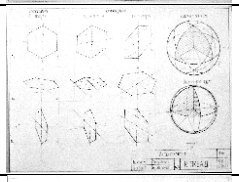
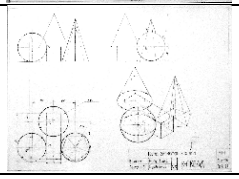
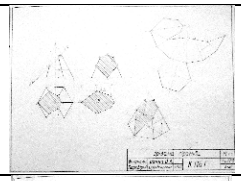
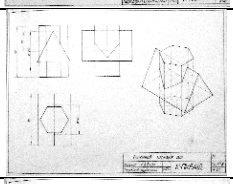
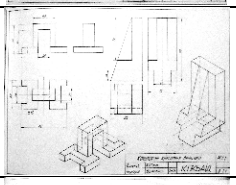
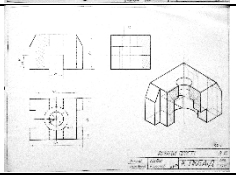


Fig. 1. Student survey forms.

III. RESULTS AND DISCUSSION

The curriculums of the disciplines "Drawing and Perspective" (D-21) and "Drawings and Descriptive Geometry" (A-21) basically have many common topics and differ little in terms of content and number of hours to study such topics. Both courses provide for similar graphic works. Joint graphic works are presented in Table 1. The table also shows the characteristics of the works, the percentage of students who passed the works without delays in the specified period, as well as the average score for the work of all studied students.

TABLE 1 INDICATORS OF JOINT GRAPHIC WORKS AND THEIR CHARACTERISTICS

№	The name of the graphic work	Format	Miniature	Execution time, hours	Submitted on time, %	Average score*
1	Drawing fonts	A4		4	80	7.8
2	Drawing lines	A4		4	91	8.2
3	Conjugation	A3		4	93	9.1
4	Projections of a point and a straight line	A3		4	92	9.6
5	Plane. Plane conversion	A3		6	82	7.5
6	Axonometric images	A3		4	95	9.4
7	Group of geometric bodies	A3		4	91	8.8
8	Cut geometric figure	A3		4	93	8.2
9	The intersection of geometric bodies	A3		6	88	8.0
10	Complex drawing of a volumetric model	A3		6	92	9.1
11	Simple cuts	A3		4	92	9.0

* according to the 12-point system

After studying all topics, students were surveyed to determine their perception of these works according to the three criteria indicated above.

The results obtained will be presented in the form of a column chart shown in Fig. 2.

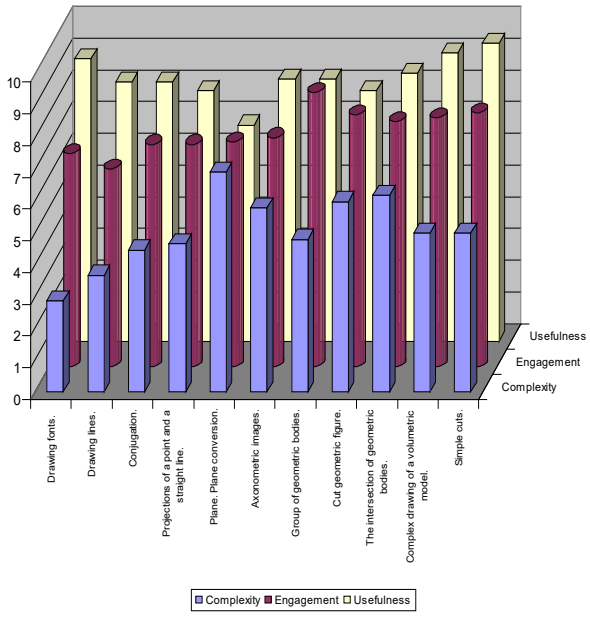


Fig. 2. Average score based on the survey results.

Figure 2 shows that according to students' responses, there is no specific dependence between the criteria of complexity, curiosity and usefulness for the future profession.

A topic that students find simple (for example, "Drawing fonts") may seem useful to them, or a topic they

consider to be least interesting (for example, "Drawing lines") can be also attributed to potentially useful ones. In contrast, a topic the students consider to be the most interesting to perform ("Group of geometric bodies") may have an average utility value.

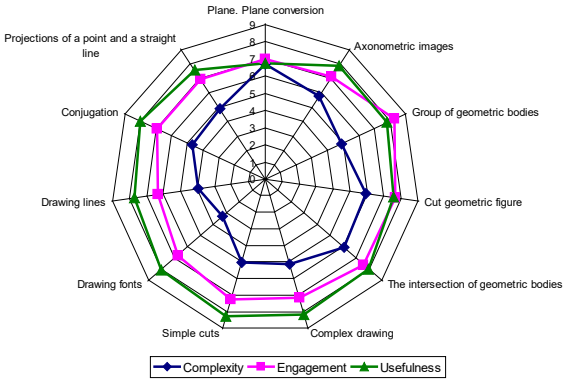


Fig. 3. Radar diagram of average scores by criteria.

The diagram in Fig. 2 demonstrates similar shifts in the average grades of students between individual graphic works, and also allows us to trace differences in the perception of the selected research criteria. We should admit a significant variation in average scores for each of the criteria, which indicates a certain imbalance, especially concerning the complexity of execution. This criterion for almost all graphic works scored the lowest marks (from 2.5 to 8), which indicates the actual assessment tested by practice (the survey was carried out after all these works were performed). Instead, the students reacted more loyally to the criterion "Usefulness for the future profession" and in fact, all the works were recognized as necessary and important for the future profession.

Having data on the success of the students' work performance (Table 1), in order to compare them with the questionnaire scores, we will convert the average score of the students into a 10-point system. By comparing them with the studied indicators (first of all with their assessment of the complexity of implementation), we will get the following diagram in Fig. 4.

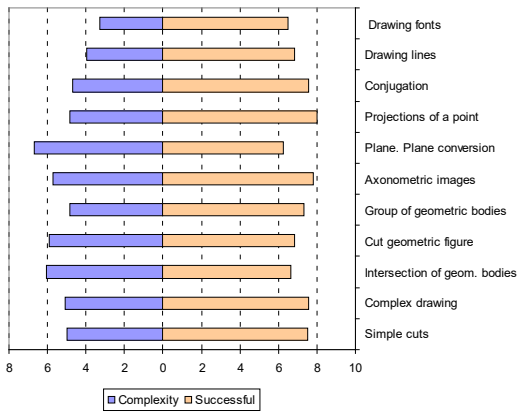


Fig. 4. Fig. 4. Comparison of the complexity of the works execution and the successful of their implementation by students.

It can be seen from the diagram that the difficulty of execution is not always directly proportionally correlated with the success of each job. Thus, we can see that the topic "Drawing fonts" did not seem difficult to the students, but the success rate was not at the highest level. While such topics as "Projections of a point and a straight line", "Complex drawing of a volumetric model" seemed quite difficult to the students, however, they generally coped with them successfully. This is due to the fact that it was not in these works that students began to get acquainted with new types of works, which at the beginning had to be well understood.

IV. CONCLUSIONS

Analysing the data obtained, we can solve several issues related to the methodology of teaching disciplines. In particular, it can be seen from the diagram that such topics as "Drawing fonts", "Drawing lines", "Point and Straight Line", and "Plane Transformation" don't arouse much interest in students. Therefore, studying these topics may be necessary to improve this component in the classroom by employing creative and interesting tasks, taking into account the peculiarities of perception and attention, etc.

The topics "Plane Transformation", "Cut Geometric Body", and "Intersection of Geometric Bodies", which turned out to be the most difficult according to students' assessments, may require more hours to study, and the topics that students consider the least useful should be reformatted or excluded from the course. To obtain more accurate results, the experts in the field of drawing should be engaged in the experiment. Further research will deal with the comparative analysis of students' and experts' perceptions of topics and various graphic works in drawing and descriptive geometry in the context of the complexity, interest in performing graphic works and usefulness of the skills acquired for the future profession.

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The Use of Virtual Reality Solutions to Improve Educational Experience for IT Students

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Abstract. **The paper is focused on the research on virtual reality solutions which could be used to improve educational experience focusing on IT students. Current state of the art in the field of VR use for educational purposes was analysed. Pros and cons for VR implementation in education were considered. As the solution to enhance educational experience was proposed to integrate VR environment with learning management system in order to automate assessment for mass-learning courses. An example of such integration, a system based on Unity engine for VR laboratory environment development, and Moodle for learning management system, was presented. Experimental results obtained during testing of developed system proved possibility of proposed integration approach and possible benefits from its practical implementation for mass learning courses.**

Keywords: augmented reality, education, learning management system, virtual reality.

I. Introduction

Virtual reality (VR) has revolutionized the way we learn, creating an immersive learning experience for students across all levels of education. As technology advances and more applications become available to educators, virtual reality solutions have emerged as a powerful tool for improving the educational experience of IT students. This paper will discuss how VR can be used to enhance IT student learning by providing them with interactive and engaging activities that help build their technical knowledge and skills. It will also explore the potential issues associated with using VR in education, such as cost, safety concerns, and accessibility challenges. Finally, this paper will provide recommendations on how institutions can best implement VR solutions in order to maximize their effectiveness in teaching IT students.

II. Materials and Methods

The study on the use of VR for education lasts over two decades. Thus, in [1] it was explored the concept of transformed social interaction in collaborative virtual environments, and how it can be used to decouple representation from behavior and form. The authors provide a thorough review of existing literature on the subject, as well as an analysis of their own experiments conducted with different types of users. They conclude that transformed social interaction has potential for creating more meaningful interactions in virtual environments, although further research is needed to determine its full impact.

A number of researches are devoted to study the possibility of using VR to improve teaching experience in specific areas. So, in [2] it was provided an in-depth review of the literature on virtual reality as a tool for teaching anatomy over decade, from 2005 to 2015. The authors analyze the various studies conducted and summarize their findings with regards to effectiveness of VR technologies for medical education. They also discuss implications of their findings, including potential limitations and areas needing further exploration. Overall, this paper provides an informative overview on how VR technology can be used to effectively teach anatomy in medical education settings. Paper [3] provides an insightful look into the potential of

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immersive interfaces for learning and engagement in education research and development. The authors discuss how these technologies offer a new way to engage students and provide them with opportunities for critical thinking, problem-solving, creativity, collaboration, and other higher order skills that are essential for success in today's world. They also describe the implications of using such technologies on student motivation as well as teacher effectiveness. The paper provides a comprehensive overview of the current state of immersive interface technology and its potential applications in educational settings. It is an important read for anyone interested in exploring this emerging field. Research presented in [4] provides a comprehensive and systematic review of the current literature on augmented reality/virtual reality technologies in higher education. The authors conducted a rigorous search to identify relevant studies, analyzing them according to their design, purpose, results and implications for educational practice. Their findings suggest that AR/VR can be beneficial for teaching and learning in higher education contexts, with potential applications ranging from problem-solving activities to virtual field trips. In [5] it was presented an extensive and comprehensive systematic literature review of Virtual Reality (VR) in education. The authors analyze the current state of VR in educational settings, and identify a variety of potential applications for this technology. They also discuss several challenges associated with its implementation, including cost, technical complexity, and lack of research evidence to support its effectiveness. Overall, the paper provides a valuable overview of the development and use of VR in educational contexts, as well as suggestions for future research directions. Another research on a topic provides a thorough review of the use of virtual reality in educational contexts from 2005 to 2015 [6]. The authors present an extensive analysis and discussion on various aspects such as the types of technologies used, advantages and disadvantages, applications, research methods employed etc. They also provide several suggestions for future research directions. Paper [7] focuses on conducted a meta-analysis on existing studies in order to determine whether or not VR was more effective than traditional methods for instruction, as well as its relative impact on student engagement, motivation, and achievement. The results show that there is strong evidence indicating that VR can be beneficial for teaching in certain contexts; however, it should be noted that further research is needed to better understand how best to use this technology in educational settings. Paper [8] presents a systematic review of the use of virtual reality in medical education. The authors conducted a comprehensive search to identify relevant studies, which were then assessed for quality and synthesized according to the type of educational intervention used. Results show that virtual reality interventions can be effective in improving student performance in medical education, with improvements seen across all aspects studied including knowledge, skills and attitudes. This review is an important contribution to our understanding of how virtual reality can be used effectively in medical education, providing evidence-based guidance on best practices for educators looking to incorporate this technology into their teaching. Also [9] provides an in-depth review of the use of Augmented Reality (AR) and Virtual Reality (VR) for teaching and learning, which is becoming increasingly popular due to advances in technology. The authors discuss various applications of AR/VR technologies across different disciplines, such as medical education, language learning, mathematics instruction, engineering training etc., and analyze the potentials and challenges associated with their implementation. They also provide a comprehensive list of evaluation criteria that should be taken into consideration when designing these systems.

So, VR can be used to improve the educational experience for IT students in a variety of ways. VR can help students visualize complex concepts, allowing them to better understand and interact with the material. For example, VR could be used to create immersive 3D simulations of networks or computer systems that allow students to explore how they work and practice troubleshooting techniques in a safe environment. Additionally, VR can be used for remote collaboration between students and teachers, facilitating real-time learning activities such as coding projects or debugging sessions. Furthermore, virtual field trips and other experiential activities using VR could provide an engaging way for IT students to gain knowledge about different technologies from experts around the world without having to leave their classrooms.

The use of virtual reality (VR) in education has been gaining traction in recent years, with many schools and universities exploring ways to incorporate the technology into their curriculums. VR can be used to enhance learning experiences by providing students with a more immersive and engaging way to explore new topics. It can also provide instructors with a platform for creating interactive lessons that allow learners to interact with 3D objects or environments. Additionally, VR can be used as an assessment tool, allowing teachers to gauge student understanding of concepts through interactions within virtual simulations.

Basing on provided review, it was analysed benefits and potential issues of VR use for educational purposes, presented below.

A. Benefits of Virtual Reality Solutions for Education

The use of virtual reality solutions in education provides numerous benefits to IT students. First and foremost, it allows learners to interact directly with objects or scenarios they are studying without having to physically visit a location or handle any materials themselves – making it easier than ever before for instructors to facilitate hands-on learning experiences remotely. Additionally, the ability to “walk through” complex concepts via 3D simulations helps one to improve comprehension by allowing learners to better visualize abstract ideas; this is especially useful when dealing with difficult topics like programming languages or coding algorithms which may otherwise be hard for some learners to grasp conceptually without visual examples in virtual environment being present. Furthermore, because most virtual reality applications come preloaded with built-in analytics tools

that track user performance data over time – including completion rate times average score per lesson – instructors gain valuable insights into how their lessons are resonating among different groups of students; thus enabling them make improvements where needed while keeping an eye on overall progress made within class cohorts at large scale level too. Finally, since many VR platforms offer multiplayer capabilities, they allow multiple users collaborate together in real time from wherever they might be located – something which could prove invaluable during group projects often assigned throughout college curriculums.

B. Potential Issues Associated with Implementing Virtual Reality Solutions

While there are numerous advantages associated with implementing virtual reality solutions into educational settings, these must be weighed against potential drawbacks if institutions are serious about maximizing its usage amongst their student body. The first issue is cost: since setting up a full-scale virtual environment requires investment not only in hardware but in software licenses also, investing money upfront can limit access for those who cannot afford it; furthermore maintenance fees may need be paid regularly to keep systems running optimally well after initial setup phase complete. Additionally, there health safety considerations which should be taken into account when deploying devices such as headsets due possibility of long-term strain caused by prolonged wearing. Lastly, some disabled individuals unable utilize certain features offered by current generation devices further limiting access for those already less privileged under circumstances to start off begin with.

Basing on analyzed pros and cons for the use of VR for educational purposes, it is possible to formulate recommendation on the VR implementation for educational purposes. In order to ensure successful implementation of virtual reality solutions into educational settings, several steps should be taken beforehand to minimize risk factors outlined above, whilst optimizing effectiveness of an end product, delivered staff members; students, etc.:

- firstly, budgeting for project needs to be done realistically taking both short term and long-term costs into account and avoid unnecessary financial burden later down line
- secondly, an appropriate training should be provided for personnel involved, so everyone should know what to expect them at each step of the process;
- thirdly, necessary safeguards should be put in place to protect users from any possible harm arising out of the usage of inappropriate content;
- lastly, regular reviews carried out in order to assess impact program had to be implemented upon outcomes desired versus actual results achieved and evaluate whether changes required to maintain optimal standards of operation moving forward.

Furthermore, VR solutions could be integrated into learning management systems such as Moodle which became quite popular during previous years of quarantine restrictions. Thus, a lot of educators are already familiar to work with them. Such integration allows teachers to create more engaging lessons for their students, while users allowed to access virtual classrooms, view 3D objects, create interactive simulations, and take part in collaborative activities with other learners. Additionally, educators can use tools like 360° video streaming or augmented reality (AR) within the Moodle LMS platform for even richer learning experiences. Also, results obtained during problem tasks completion in VR environment could be automatically passed to Moodle LMS simplifying assessment process for teachers.

In the following chapter an example on such integration proposed by authors is discussed.

III. RESULTS AND DISCUSSION

Basing on the results gained during provided analysis, it was developed custom solutions for VR laboratory and Moodle LMS integration on the base of Turiba University ITN department. VR laboratory was implemented using Unity game engine. VR laboratory includes virtual environment used for teaching IT-related courses and includes HP reverb G2 Virtual Reality Headset to provide the best learning experience for students. In order to automate assessment process, it was developed approach to pass the grades obtained on the problem task completion to the database, and the use of this data to fill appropriate grades in the Moodle LMS.

The integrated environment operates in the following way. Course instructor should define objectives in the Moodle system, which are saved in the database and reflected for student in Moodle environment. Students start execute problem sets solution in Unity virtual environment, where all objectives are reflected for the user (fig. 1).

Fig. 1. VR environment in Unity showing all objectives completed.

Upon objectives completion, the number of achieved goals updated in the database and reflected for the user. Finally, upon all objectives completion or time limit event, virtual simulation program completes, and final data are saved to the database, as well as final result reflected in the Moodle LMS (fig. 2).

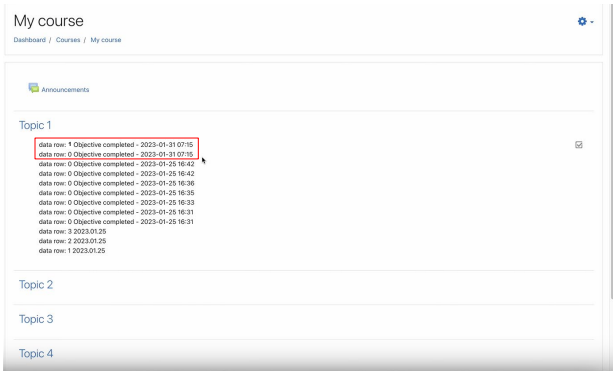

Fig. 2. Moodle environment showing progress on objectives completion.

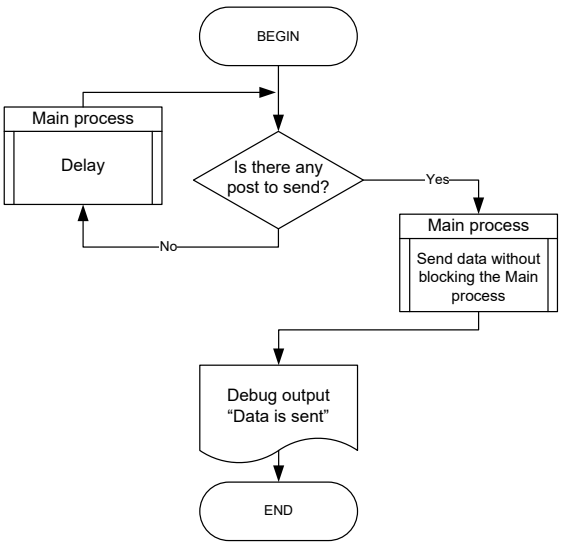

Fig. 3. Flowchart of data exchange process between VR environment and the database.

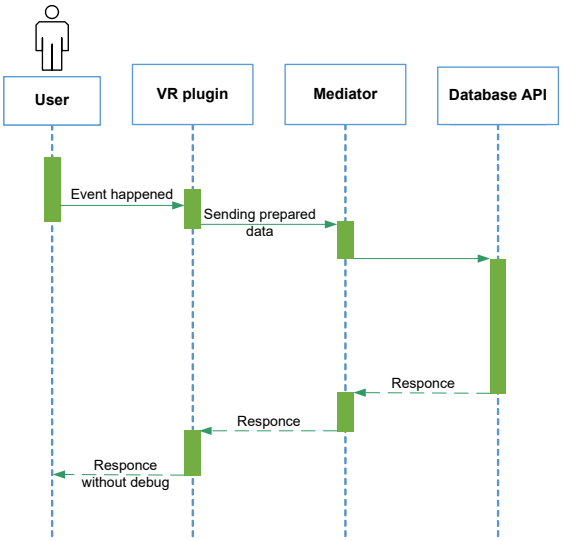

Fig. 4. Sequence diagram showing data exchange between VR environment and the database.

The flowchart showing the process of data exchange between VR environment and the database is presented in fig. 3. The process was implemented to achieve normal flow of the main simulation process in VR environment without interrupts and presented in sequence diagram (fig. 4).

Database contains three main tables containing information about students (Users), set of actions which could be implemented in the system (ActionGroups) and list of action performed by each user (Actions), which is used to reflect completion data in the Moodle system (fig. 5).

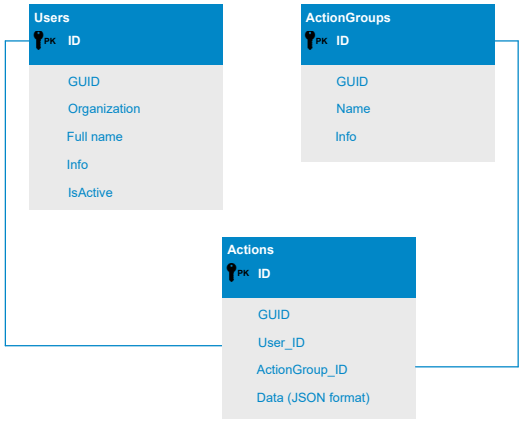

Fig. 5. Database tables.

Experimental verification of the system provided with involvement of Turiba University ITN department students showed increase in student involvement into learning process, along with better grades obtained compared to previous years students. However, there is no enough data to analyse systematic dependencies on the influence of VR solution implementation on students' grades improvement in general. Thus, further researches will be provided on the base of developed solutions.

IV. Conclusions

Overall incorporating virtual realities programs into learning environments offers great potential to improve quality of instructions given to IT students. However, careful planning preparation must go into undertaking to ensure maximum benefit derived minimal risks. The paper proposes one of the possible solutions to improve VR solutions experience by means of VR integration with Moodle LMS. Such approach is promising, especially in modern age of mass-learning courses, when it is quite important to automate as much processes as possible in teaching instruction execution and students' results assessment. Further researches will be related to proposed approach effectiveness comparison with traditional approaches, providing tests involving tested student groups.

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