Being Well and Striving Steady at Work – The Relationship of Social Support and Self-Concordant Goal Selection with Teacher Burnout

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Abstract: Teacher burnout is influencing the quality of teaching and the connection of teachers with their students, thus it is a phenomenon worth paying attention to. In the past, researchers showed that following goals that are intrinsically motivated, can work as protective factors for burnout syndrome. The present study investigates the relationship between teachers' burnout level and the motivational background behind their professional goals. We assumed that autonomous motivation in goals will be associated with low burnout level, and controlled motivation in goals will be associated with high burnout level. We assumed that positive emotions and social support are related to goals with autonomous motivation, and negative emotions are related to goals with controlled motivation, and we tend to create two clusters accordingly. We assumed that the negative cluster will be associated with high burnout level, and positive cluster will be associated with low burnout level. The results strengthened all of the hypotheses. High and medium burnout levels were associated with the negative cluster, and low burnout level was associated with the positive cluster. The present study provides a contribution for understanding the protecting factors for teacher burnout, and brings awareness on how teachers' work-related goals is connected to burnout syndrome.

Keywords: teacher burnout; intrinsic motivation; social support

1 Introduction

"The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires." (William Arthur Ward)

We are living in the age where it became important to care about not just our physical, but our mental health as well. Workplaces are more likely willing to pay attention to how their employees are doing while doing their job. However, this is

mostly true in the private sector in Hungary. In the case of teachers, nurses, and doctors, who are operating under governmental control, there is usually less attention and less material resources to care for employee's mental health. In contrast, burnout syndrome was discovered first and most prominently in the human service sector [1].

In this article, we bring more attention to the mental health of public education teachers in Hungary. Burnout syndrome is present among them, yet they have an important task and a big responsibility, to give good examples, educate, and be role models for the next generation. Previous studies investigated how job circumstances are influencing burnout development at teachers. Grayson and Alvarez [2] found that conflicted relations among students, administrationl obligations, teachers' own problematic relations with students are all contributing to the development of teacher burnout. Foley and Murphy [3] in their research added, that the lack of order and organization in the classroom is also playing a role in teachers' burnout development. There are a lot of risk factors in teachers' work. In addition, it seems that there are less fewer less people in Hungary who are willing to commit to become a teacher, according to the data of the central statistical office (https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_zoi010b.html). This results in diluting quality of graduated teachers.

In our research we explored the motivational factors behind teachers' professional goals based on the SDT theory and the Self-concordance model, and we investigated their effect on the burnout levels of teachers. We applied an approach and an assessment tool – the Personal Goals and Plans Inventory, based on the Self-concordance model – which hasn't been investigated in connection with burnout syndrome previously. The inventory measures the motivational background regarding professional goals, and the positive or negative emotions that are associated with them, as well as social support related to them. We hope that our work will contribute to a mentally healthier and more inspiring teacher community, and maybe motivate more people to choose this occupation as their vocation.

1.1 Burnout Syndrome

Burnout is a condition of emotional and mental exhaustion, it is the feeling of helplessness and incompetence, loss of goals and purpose, and the development of negative attitudes toward one's work, self and others [4]. Burnout unfolds by an elongated period of time (months or years), and as a result of chronic stress experienced by the individual. In their study, Maslach et al. [1] created an assessment tool for burnout (the MBI), in which three major dimensions were defined: emotional exhaustion (when one has low energy and is feeling drained), depersonalization (a negative, cynical attitude towards one's clients) and reduced personal accomplishment (the tendency to evaluate oneself negatively, especially in one's work with clients). It is unquestionable that when teachers are developing

burnout syndrome, it has a bad effect on their students. Burnout was discovered first among the employees of the human service sector (through interviews with hospital nurses), but shortly after developing MBI-HSS, the educators' survey of MBI (MBI-ES) had been created [5].

The developmental process of burnout was investigated by various studies, e. g.: [4], [6], [7]. While the former ideas investigated only personality-related factors in burnout development, the latter ideas considered burnout as a result of insufficient balance of job demands and job resources [6], which brought work environment factors into the focus as determinants for burnout development. In the model of Leiter [7], work environment characteristics are influencing both emotional exhaustion and personal accomplishment dimensions of burnout, and these burnout factors are developing parallel throughout time. In Leiter's model, depersonalization can be viewed as a reaction, a non-adaptive coping mechanism to chronic stress experienced by the individual, and it is in direct connection with emotional exhaustion. A work environment factor, social support – which will be examined in the following – can be observed in this model as a negative influence regarding the development of depersonalization, and a positive influence on perceived personal accomplishment.

1.1.1 Teacher Burnout and Its Relation to Social Support

One of the first pioneers in burnout research, Herbert J. Freudenberger published the 12 step progress model of burnout [4]. According to the model, burnout starts with an excessive desire to prove in one's occupation. This exhausts one's energy supplies, and soon one's personal relationships start to deteriorate. Thus, support from friends and colleagues may disappear in lives of people with burnout syndrome. However, Leiter [7] in his study pointed out that social support has a major role in the development of burnout syndrome as a protecting factor (see Fig. 1), because it has a negative effect on the development of depersonalization and a positive effect on personal accomplishment. Several studies confirmed this finding regarding teacher burnout, e.g. [8]-[12]. Most of them found connection with all three dimensions of burnout, and found that support can serve as a protecting factor for burnout. Besides, Avanzi et al. [13] found that dedicated teachers receive more support in their work than non-dedicated ones. As previous studies showed [11], colleagues and principal's support is a great supply for teachers in their battle against burnout. In our study, we investigated professional and emotional types of support in work-related goals.

1.2 Motivational Background of Professional Goals

As Avanzi et al. [13] pointed out, dedicated teachers tend to get more support at work. Dedication is connected to one's work performance and goals. Is there a direct connection between teachers' burnout and the motivation behind their work-related goals? In the followings, we take a closer look at this question.

1.2.1 The Self-Determination Theory

In order to investigate how personal goals effect burnout, first, we examine Deci and Ryan's Self Determination Theory (SDT in the followings) [14]. The authors defined three basic needs that an individual is willing to fulfill: need for competence, need for relatedness, and need for autonomy. The way individuals satisfy these needs might have different motivations behind. The authors named amotivation, extrinsic motivation and intrinsic motivation as types of motivation. While amotivation and intrinsic motivation are ends of the motivation spectrum as amotivation indicates unconscious actions without motivation, and intrinsic motivation indicates an action that is fuelled by one's interest and enthusiasm, extrinsic motivation has different kinds of regulation types according to how close extrinsic motivation is to intrinsic motivation – i. e. how internalized the extrinsic goal is – on the spectrum. Accordingly, extrinsic motivation includes external regulation (when one does something to satisfy the pressure from the environment), introjected regulation (when there is some value in the activity for the individual, but the main reason is still to avoid a constraint), identified regulation (when one consciously values a goal) , and integrated regulation (when one feels that the goal or activity is personally important but it doesn't reach intrinsic motivation).

Deci and Ryan named the self-controlled regulations „autonomous" and the environment controlled regulations „controlled". Accordingly, external regulation and introjected regulation are part of „controlled" reason, because they are motivated by either rewards or constraints from the environment or one's own ego satisfaction. On the other hand, identified regulation, integrated regulation, and internal regulation (connected to intrinsic motivation) are part of autonomous reason in the SDT, because they are controlled by the individual him/herself [14].

2.1.1 Self-Concordance Model

The question may be – why would anyone follow a goal only because of pressure from the environment, when one does not see any value in it and when it gives no joy and satisfaction? The reason was investigated by Sheldon and Elliot [15]. In their model, they refer to a "self", which is similar to the idea of "transcendent function" of C. G. Jung, that is a more or less stable mental construction, and has the potential to control one's bio-cognitive thinking processes (conative processes). It means that we have a capability to decide out of a "higher" mode of consciousness, which is integrated and considers everything that matters to us. This way, one can maximize one's organismic need satisfaction. It may occur, however, that individuals select goals that are not representing the values and interests of this integrated self, because during decision making, they may be out of touch with it. Then, individuals start to follow goals that are not based on their true interests and values.

The actions and goals that rise from the integrated self – Sheldon also calls it "implicit personality" [16], are called self-concordant goals. The goals rising from the non-integrated self are called nonconcordant goals. Self-concordance model (SCM) is in connection with the previously introduced SDT by Deci & Ryan. According to SCM, intrinsic and identified regulation-goals are self-concordant goals, and introjected and external regulation-goals are nonconcordant goals. Sheldon [16] discovered, that "not all progress is beneficial" in one's goal pursuing, and that self-concordant goals are also influencing one's well-being, since individuals who follow nonconcordant goals reported negative emotional predominance after a period of time. In contrast, individuals who followed self-concordant goals, had higher well-being and were more positive emotionally. Elliot has a similar idea in his Goal Orientation Theory [17]. He implements the expression „mastery goals" for goals that lead to positive feelings, and „achievement goals" for goals that lead to negative feelings.

1.2.2 Self-Concordant Goals and Teacher Burnout

In the following we will introduce studies that investigated teacher burnout along with either the SDT or in relation with the SCM.

Fernet et al. [18] developed the Work Task Motivation Scale for Teachers (WTMST), which is based on the SDT model, and explores six work-related motivational factors of teachers (e.g.: class management, teaching, class preparation, evaluation of students). In the validation process of WTMST (Fernet et al. 2008), researchers included burnout measurement, and correlated the two constructs. The results showed that the correlations between burnout and the work-related task motivations show a pattern in line with the SDT theory: autonomous reason tasks were in reversed connection with progressed burnout, and controlled reason tasks had linear relationship with it.

In a longitudinal study of Julia Reid [19], the aim was to renew teachers' professional and personal identity, by delivering a development-focused program with personal meetings throughout 3 consecutive months. There were 6 sessions during the 3 months. In the course of the renewal process, a value-based inventory (the AVI – reference: https://www.minessence.net/avaluesinventory/AVI.aspx #.XkE5QzFKhPY) was applied, and analysed for participants, which revealed their unconsciously held, yet important values and interests for them. By aligning the important values with their professional goals, participants' well-being raised, and by the end of the program, their vitality was significantly higher than before [19].

2 Hypotheses

Based on the findings we introduced above, we made the following presumptions:

1) To confirm the results of Fernet et al. [18], we hypothesize that from the intrinsic toward the external regulations in goals there will be a linear relationship with burnout levels. We presume that external and introjected regulation will associate with high burnout level, identified and intrinsic regulation will associate with low burnout level.

2/a) To confirm the SDT model's and the SCM model's assumptions, we intend to create two separate clusters out of the motivational background of teachers' work-related goals. We presume that intrinsic and identified regulation-goals (i.e. autonomous reason-goals) will form a cluster together, and external and introjected regulation-goals (i.e. controlled reason-goals) will form another cluster together [14], [15].

2/b) We presume based on the findings of Sheldon [16], that positive emotions will be in the same cluster with self-concordant goals, and negative emotions will be in the same cluster with non-concordant goals.

2/c) We also presume that self-concordant goals (and positive emotions) will be in the same cluster with professional and emotional social support [13].

3) Our next hypothesis builds on our second hypotheses – it concerns the clusters' correlations with burnout syndrome. We presume that high burnout level will be associated with non-concordant goals and negative emotions, and low burnout level will be associated with self-concordant goals, positive emotions, and professional and emotional social support [18] – in case if our second hypotheses are confirmed.

3 Methods

3.1 Participants

The assessment was conducted with the help of the Institute of Applied Pedagogy and Psychology at Budapest University of Technology and Economics. The Institute has a postgraduate program for teachers in the public education. Teachers are attending this program from all over Hungary. Among them our sample was formed.

3.2 Measures

3.2.1 MBI-ES (Maslach Burnout Inventory – Educators Survey)

Teachers' burnout level had been assessed with the Maslach Burnout Inventory, Educators Survey [5]. In this inventory, participants have to answer 22 items on a 7-point Likert scale, about how frequently they experienced a certain symptom of burnout recently (e.g.: I feel that my work is emotionally draining. – statement for emotional exhaustion). 0 means: never, 6 means: every day. We asked permission to include MBI-ES in our study from MindGarden, the owner and distributor of the MBI assessment. The MBI-ES has been validated by Szigeti et al. [20] in Hungary. The Cronbach α was 0.86 for emotional exhaustion, 0.64 for depersonalization and 0.76 for personal accomplishment. In every dimension, there was a "low", "medium" and "high" category, which is defined by the international standards. In our study we worked with overall burnout scores. In order to distinguish between the low, moderate, and high levels of overall burnout, we applied the following categorization (see in Table 1):

Table 1
Creation of overall burnout levels (by "dimension" we mean: emotional exhaustion, depersonalization, personal accomplishment). It does not matter *which* dimension is scoring low/medium/high for categorization.

	Grouping criteria
Low burnout level	low on all dimensions; low on two dimensions, moderate on one dimension
Medium burnout level	moderate on all dimensions; moderate on two dimensions, low on one dimension; high on one dimension, low on two dimensions; moderate on two dimensions, high on one dimension
High burnout level	high on all dimensions; high on two dimensions and moderate or low on one dimension; high on one dimension, moderate on the second dimension and low on the third dimension

3.2.2 Personal Goals and Plans Inventory

Personal Goals and Plans Inventory was created based on the SCM model by Sheldon & Elliot [15]. We chose this inventory because it builds on the four regulation types of SDT, included in the SCM: internal regulation, identified regulation, introjected regulation and external regulation. By filling out the inventory, participants have to list 4-6 personal goals that they would like to achieve within the next 3-6 months in their profession. Then, the 3 most concerning/important goals should be picked out, and each one of them should be rated about the background motivations, emotional associations and work

circumstances regarding the goals. There are 22 items altogether, and answers are checked on a 7-point Likert scale (1: not true, 7: absolutely true). We only included items in our analysis that were measuring what we intended to investigate: we included four items, for the motivational aspects of goals (based on the SDT model): intrinsic regulation, identified regulation, introjected regulation, and external regulation; two items that measure positive and negative emotions associated with the goals; and two further items about social support (emotional and professional), regarding the picked out goals. In Hungary, several studies have been conducted with the Personal Goals and Plans inventory, with satisfactory reliability coefficients, e.g.: [21]-[23]. Since it was applied in a modified form (some items were excluded) in our study, reliability (Cronbach-alpha) values will be introduced in the 'Descriptive statistics' part of 'Results'.

4 Results

4.1 Descriptive Statistics

In Table 2 the distribution of the sample is presented. We have a female-dominant sample, which is a typical ratio in the teacher community in Hungary. The average age is 46, which refers to a middle-aged population, and one-third of the sample is a manager teacher (principal or VP). 16,2% of participants are teaching in public schools of Budapest, 25,3% in capital towns of counties, 40,9% in towns, and 17,6% in village schools. The average teaching experience in our sample is 17 years, and the standard deviation is 8,6, so most of the participants have at least about 10 years of experience.

Table 2
Descriptive statistics of the sample

N=494		
Gender	Male	97 (19,6 %)
	Female	397 (80,4%)
Age (years)	mean=46 SD=7,6 Min.=26 Max.=64	
Role	Principal or deputy	167 (33,8%)
	Teacher	327 (66,2 %)
Township (insitution's)	Capital city	80 (16,2%)
	County capital	125 (25,3 %)
	Town	202 (40,9 %)
	Village	87 (17,6 %)
Experience in years	mean=17 SD=8,6 Min.=0 Max.=38	

Reguarding the descriptives of the applied inventories in the study, the Cronbach's alphas of the MBI-ES were: 0,872 for emotional exhaustion, 0,691 for depersonalization and 0,834 for personal accomplishment. In Table 3, the low-moderate high-level distribution is presented regarding the dimensions of MBI-ES [24]. Our sample measures highest on the emotional exhaustion dimension, and on the other dimensions the scores are generally low. This means that we have a relatively healthy, but somewhat emotionally drained sample.

Table 3
Distribution of the sample within the MBI dimensions

Emotional exhaustion	**high**	**18,2%**
	moderate	27,5%
	low	54,2%
Depersonalization	high	2,2%
	moderate	6,3%
	low	91,5%
Personal accomplishment	high	0,4%
	moderate	0,4%
	low	99,2%

The overall-burnout levels were created as it was seen in 'Methods'. There was no case where all dimensions measured high, and there was no example for the combination when two dimensions measured as moderate and one as high. Among the cases, 395 fell into low, 65 into medium and 34 into high overall-burnout levels. In case of Personal Goals and Plans Inventory, participants had to mark their answers three times for each items (regarding each of their selected professional goal). We provide the Cronbach's alpha values for autonomous reason (intrinsic and identified regulation), and controlled reason (introjected and external regulation), and the rest of the included items separately (see in Table 4). In the analysis, we worked with average values of all the included items.

Table 4
Cronbach's alpha values of the items of Personal goals and plans inventory

	Cronbach's alpha
Autonomous reason	0,731
Controlled reason	0,809
Positive emotions	0,632
Negative emotions	0,603
Emotional social support	0,767
Professional social support	0,733

4.2 Burnout Levels and the SDT Model

For data-analysis we applied SPSS 25 software. Because the distribution of the sample failed the normal distribution, we applied Kruskal-Wallis test to investigate the connection between burnout levels and motivational factors of work-related goals. Then, we applied Mann-Whitney U tests to have a clearer understanding of our results. According to the results of the Kruskal-Wallis test, when the four regulation-types (intrinsic, identified, introjected, and external) were related to the three burnout levels, the results were significant ($p<0,001$) in all cases. By applying Mann-Whitney U tests, we created pairs of the three levels of burnout (low-medium/low-high/medium-high) and related them to the regulation types to discover the differences more precisely. The results are presented in Tables 5, 6, and 7. First, we related low and medium burnout levels regarding the four regulation types. Almost all regulation types are significantly differs regarding low and medium level burnout (see in Table 5). The rank values let us conclude the direction of the difference: in the case of introjected and external regulation, the rank values were higher, and in the case of identified and intrinsic regulation the rank values were lower. The directions were similar in the other Mann-Whitney U tests as well. However, between medium and high burnout levels, there was no significant difference regarding the regulation types, with one exception, identified regulation (see in Table 6). This points out that medium and high burnout levels are both associate with low-level of autonomous reason and higher level of controlled reason when following professional goals. Identified regulation means that one is seeing a value and a meaning in one's work, and this is significantly less prominent in the high burnout level group, which means that participants who has medium burnout level see more value and meaning in their work compared to participants with high burnout level. When comparing low and high levels of burnout (Table 7), all variables were significant, except external regulation. This may be a surprising outcome, as medium and low burnout levels differed significantly regarding all variables. This result points out that the values (and rank numbers) of external regulation were somewhat lower in high-level burnout-cases than medium level burnout-cases. This phenomenon might be a characteristic feature of this sample, yet reassures that there is little deviation between medium and high burnout levels with regard to most of the variables of goal-motivation.

Table 5
Results of Mann-Whitney U test (grouping variables: low and medium burnout level). Cases marked with a '*' are significant.

	Extern. reg.	**Introj. reg.**	**Ident. reg.**	**Intrins. reg.**
Mann-Whitney U	10138,5	9303,5	10874,5	8465,50
Wilcoxon W	88348,5	87513,5	13019,5	10610,50
Z	-2,724	-3,601	-2,053	-4,419
Asymp. Syg. (2-tailed)	0,006*	p<0,001*	0,040*	p<0,001*

Table 6
Results of Mann-Whitney U test (grouping variables: medium and high burnout level). Cases marked with a '*' are significant.

	Extern. reg.	**Introj. reg.**	**Ident. reg.**	**Intrins. reg.**
Mann-Whitney U	1082,00	900,00	834,00	1095,50
Wilcoxon W	1677,00	3045,00	1429,00	1690,50
Z	-0,170	-1,516	-2,021	-0,070
Asymp. Syg. (2-tailed)	0,865	0,130	0,043*	0,944

Table 7
Results of Mann-Whitney U test (grouping variables: low and high burnout level). Tests marked with a '*' are significant.

	Extern. reg.	**Introj. reg.**	**Integr. reg.**	**Intrins. reg.**
Mann-WhitneyU	5553,50	3770,00	4079,00	4264,50
Wilcoxon W	83763,5	81980,00	4674,00	4859,50
Z	-1,678	-4,299	-3,939	-3,547
Asymp. Syg. (2-tailed)	0,093	p<0,001*	p<0,001*	p<0,001*

4.3 Cluster Analysis

In order to create the clusters, first we created standardized values (Z-scores) for the included items of the Personal Goals and Plans Inventory, in order to be able to be compared with one another. Then, we did K-means exploratory cluster

analysis, which classified the selected items into 2 clusters. Cluster membership was defined by positive values of the variables in each of the two clusters. The results turned out as we expected: positive emotions, emotional and professional social support, identified regulation and intrinsic regulation became members of the same cluster, whereas negative emotions, introjected regulation, and external regulation became members of another cluster. The strongest defining variable of a cluster has the highest positive value. In the first cluster it is intrinsic regulation, in the second cluster it is negative emotion. We named the clusters *'positive'* and *'negative'*, and cluster memberships were saved as a new variable in order to be applicable for further analysis.

To investigate the clusters' correlations with the three overall-burnout levels, we applied crosstabulation (Chi-square test). We found that the two clusters associate to burnout levels as we expected: among low burnout level cases, 265 cases associated with the Positive cluster, and 130 with the Negative cluster. In the case of medium and high burnout levels the ratios turned, as 22 and 5 cases associated with the first, and 43 and 29 with the second cluster. The Chi-square test was significant. The strength of the relationship between the variables was measured by the Cramer's V coefficient. Its value was V=0,320, which indicates a moderately strong relationship. The results of the crosstabs are illustrated in Figure 1 as well.

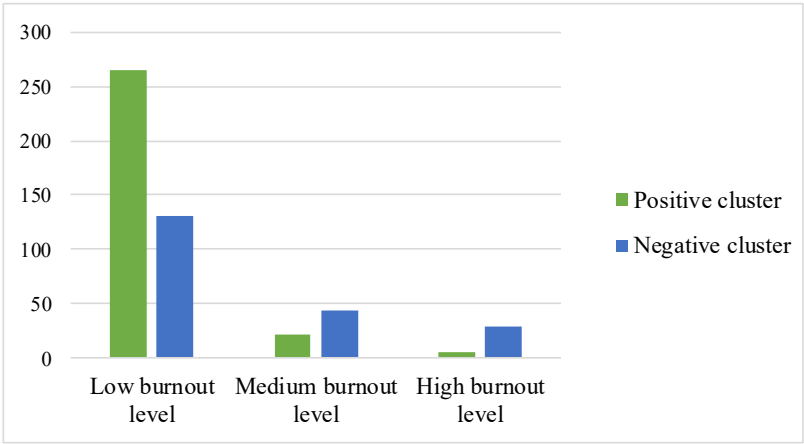

Figure 1
Results of the crosstabulation (burnout levels and clusters)

Conclusion

Based on the results of the Mann-Whitney U tests, we found that autonomous reason goals associated with low burnout level, and controlled reason associated with medium and high burnout levels, which confirms the results of the study of Fernet et al. [18]. There were significant differences between low and medium

burnout levels with respect to the regulation types, but there were no significant differences between medium and high burnout levels, except one variable: identified regulation. It means that in our sample, there is a "low burnout" group (low burnout level) and there is a "progressed burnout" group (medium and high burnout levels together), since they didn't have significant difference, and it was also confirmed by the results of the Chi-square test as well. In crosstabulation, the two levels associated similarly regarding the two clusters. From the Mann-Whitney tests we could also draw the conclusion that considering professional goals as meaningful is still true in the medium burnout level-group, but not any more in the high burnout level group.

In the cluster analysis, clusters were formed as we expected in Hypothesis 2: identified and intrinsic regulation in goals fell into the same cluster (as autonomous reason). We could also confirm the results of Sheldon and Elliot [15], that positive emotions are associated with only self-concordant goals (as they shared the same cluster), and negative emotions were forming a cluster together with introjected and external regulation in goals (as controlled reason), so in those cases it is true that negative feelings are associated with feeling obligated to accomplish a goal (controlled reason).

As for social support, it associated with low-level of burnout, and the higher the burnout level, the lower social support is (regarding the results of the crosstabulation). This result reassures the findings of Freudenberger [4], who described in the 12-step model of burnout the part when interpersonal conflicts start to emerge – thus social support may deteriorate.

With regard to the connection of social support and motivation, Avanzi et al. [13] findings was also confirmed by our study, that dedication in work (measured as autonomous reason in goals) is associated with social support, as these variables became members of the same cluster.

As a conclusion with regard to our results, we could point out that there is a clear connection between the progressive levels of burnout and the motivational background of teachers' work-related goals. With burnout syndrome, goals become less important, less interesting and more feeling like unwanted obligations to the individual. This is a big issue at teachers' work since almost all of their goals are connected to educating children. Moreover, as Avanzi et al. [13] pointed out, dedicated teachers tend to have more social support. We believe that our article puts attention on an important issue. It also gives a foundation to the development of future burnout intervention programs, which may include the internalization of goals, as previously it was already proven to create professional renewal of teachers by internalizing their work-related goals [19].

Limitations

The limitations of the present research are that the sample regarding the burnout levels is not balanced: there are more cases in the low burnout level category than the other two. This may be due to the social desirability motivation of teachers.

Because of their work, teachers may think that they have to be all time role models for children and for society, and thus they have to be flawless. The uneven distribution of the sample may have influenced that we didn't find any significant differences between medium and high burnout levels, and that at one variable (external regulation) scored higher in medium level burnout cases than highlevel burnout cases. With a better distributed sample we could probably draw more distincted conclusions. It was also interesting and might be the subject of further investigation, why our sample was distributed between all the low, medium and high levels of the emotional exhaustion dimension of burnout, but there was no or little number of cases in medium and high levels of the other dimensions, depersonalization and personal accomplishment. It might be a characteristic of the teacher population in Hungary, but it is also possible that new standard values should be formed for the different levels of burnout dimensions regarding the teacher population in Hungary, in order to have an even distribution regarding the three levels. It would also be worth to look at burnout by the institution type and comparing the results with the fields of secondary education, vocational education and higher education. This way we would get a better understanding of burnout syndrome among all kinds of teachers in Hungary. When applying statistical analyses, the sample failed the normal distribution. Therefore, Variance analysis could not be applied, which may have led to less reliable results. The main limitation of our study is its cross-sectional nature, which includes biases of self-reporting and the inability to predict causality. However, in order to have a clearer understanding about the cause and effect relationships between the measured variables, Structural Equation Modelling is suggested for further investigations.

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Developing Visual Perceptual Skills with Assistive Technology Supported Application for Children with Cerebral Palsy

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Abstract: Visual perception (VP) allows us to process visual stimuli to identify what we see and, thus, understand the world in which we live. VP ability is one of the many cognitive areas often affected in children with cerebral palsy (CP). VP deficits may lead to difficulties in learning, recognizing, and remembering letters and words and learning basic mathematical concepts. We created and applied special educational software for children with CP to develop their VP skills. This study aimed to investigate the long-term effects of the software we created to develop the VP skills of CP patients. We randomly assigned 18 participants to equally sized intervention (n=9) and control (n=9) groups and another 12 typically developing samples to compare VP skills. The duration of the intervention was 15 minutes, three times a week, for one school semester (9 months). We used the Motor-Free Visual Perception Test – 4 (MVPT-4) before and after the intervention to evaluate the VP skills, combined with eye-tracking to identify gaze patterns that provide valuable information on the participants during the test solving. Due to the small sample size, we did not expect significant changes, but a positive tendency is captured in the VP skills of the intervention group. We found significant differences ($p<0,001$) in comparing VP skills of typically and atypically developing children. In this study, we present only preliminary results of the eye-tracking data, which seems an appropriate method combined with the MVPT-4 assessment.

Keywords: special educational application; visual perception; cerebral palsy; MVPT-4; eye-tracking

1 Introduction

For children with physical and cognitive disabilities, information and communications technology (ICT) is indispensable. Our main aim was to develop

and apply educational applications for children with cerebral palsy (CP). CP is a movement disorder characterized by permanent damage to the development of posture and movement caused by non-progressive disturbances that occur during fetal or infant brain development [1]. CP can be classified by functional ability and by neurological subgroup, which is determined according to the limbs affected (hemiparesis, tetraparesis, diparesis), clinical signs and symptoms (spasticity, dyskinesia or ataxia), and muscle tone (hypotonic, or hypertonic) [2] [3]. There are often sensory, perception, cognition, communication, and behavior problems associated with CP. It is the most common childhood physical disability and affects 2 to 2.5 children per 1,000 born in western countries [1] [4] [5]. Studies dealing with CP tend to focus mostly on motor impairments and neglect the impact of cognition, like visual perception on functional ability [6] [7]. Visual perception allows us to process visual stimuli to identify what we see and, thus understand the world in which we live. Visual perceptual ability is one of the many areas that is often affected in children with CP [8]. A study by Schmetz et al. [9] found that children with CP aged 5-18 years experience persistent deficits in visual perception or visual perceptual impairment (VPI) compared with typically developing children. Visual perception includes several specific subsections (e.g. visual discrimination, visual form-constancy, figure-ground). All of these subsections contribute to visual perception and have important implications for functional tasks. This specific subsection and the characteristic of CP – different lesion patterns in the brain – indicate that there is no accepted prevalence rate of VPI in children with CP [10]. In children with CP, perception deficits can affect their academic performance in regard to reading ability and learning as well as activities of daily living (ADL), such as dressing [8] [11] [12]. The relationship between motor-visual and visual-motor development is powerful, and CP can lead to both impaired motor skills and perceptual and cognitive visual impairments [8] [13] [14].

In recent years, with widespread access to information, advances in ICT applied to the education sector are changing to traditional approaches to special education and early intervention [3] [15]. These findings lead us to create an application that supports visual perception skills development.

2 Features of the Application

The idea of developing these applications came from the daily practice of conductive education (Pető Method) – demand-driven project – lack of software for early intervention, sub-skills development, e.g. visual-auditory perceptual skills.

2.1 Technical Features

In the course of development, special attention was paid to running the software on many kinds of IT assistive technology such as eye-tracking, switch technology, and special mouse - to open the door for the main target group – for children with severe physical disabilities.

Applications are running on PC (web-based) and on tablets (IOS, Android). The software collect statistical data about users, so positive change and problematic areas become observable. It gives the parents/teachers real-time feedback about the children's performance. Beyond the functional software design, usability and ergonomic features were also considered to assess these software positive effect on cognition, especially for visual perceptual skills. Another essential feature is gamification to get and maintain the user's attention and motivation. The design and the characteristic of the user interface fit the needs of the children – playful, colourful, different levels of difficulty and reward collection opportunities.

2.2 Main Targeted Developmental Areas

- Visual perception skills: such as visual discrimination, spatial relationships, visual memory, figure-ground, visual closure, perception and recognition of colours and shapes.
- Auditory perception skills: such as auditory closure, auditory conceptualizing, auditory discrimination, auditory memory, and auditory sequential memory.
- Basic mathematical operations (summations, subtractions), and problem-solving skills,
- On tablet: eye-hand coordination, fine manipulation, hand dominance,
- Rule consciousness,
- Decision making skills,
- Self-awareness.

3 Materials and Methods

A matched-pairs control randomized controlled research investigated the effectiveness of special educational software, learning games created to enhance different kinds of sub-skills of preschool and elementary school children with typical and atypical development (e.g. CP). The intervention period was a school

year (9 months); during this period, the participants belonging to the intervention group were allowed to play with the applications for 15 minutes at least three times a week. This time-frame was set up together with the specialist and teachers, and it fits the daily schedule of their daily conductive educational program. The control group did not use the applications; they participated in their conductive educational program.

3.1 Participants

The participants, aged between 4-8 years (mean 6.77), came from the András Pető Faculty Elementary School and Kindergarten. The extent of the observed group N=18, test group N=9, control group N=9. By diagnosis: Tetraparesis: N=6, Athetosis: N=2, Ataxia: N=2, Hemiplegia N=2, slightly affected developmental disorders: N=6. Participants who consented to the study were matched in pairs based on age and the type of diagnosis. The sample size of the intervention group is small. but not unusual in this patient population.

We also conducted the baseline measurement (MVPT-4 test and eye-tracking) with typically developing (N=12) children to analyze and compare this population's visual perceptual skills and gaze patterns.

3.2 Research Tools

3.2.1 Motor-Free Visual Perception Test – 4 (MVPT-4) (Colarusso & Hammil, 2015)

The MVPT-4 is a revised version of the MVPT-third edition, the original version of the MVPT was developed in 1972. It was revised to the MVPT-Revised (MVPT-R) in 1996, the MVPT-3 in 2003, and the MVPT-4 in 2015. The MVPT-4 was designed to assess the visual-perceptual ability of individuals aged 4.0 through 80+ years via a series of visual-perceptual tasks that do not require a motor response [16] [17]. The test assesses five visual perceptual abilities: visual discrimination, spatial relationships, visual memory, figure-ground, and visual closure. The scores from these subtests cannot be calculated alone; instead, they are summed together in one overall visual perceptual ability standard score. Colarusso and Hammill - the test's authors - reported that MVPT-4 is a quick, accurate, reliable, and valid assessment of overall visual perceptual ability [18]. Stimuli are composed of black-and-white line drawings and designs, with answer choices presented in multiple-choice format.

3.2.2 Eye-Tracking

Tobii Pro X3: Screen-based eye tracker capturing gaze data at 120 Hz, an unobtrusive and direct technique that allows researchers to not rely exclusively on self-report measures [19] [20]. We digitalized the test sheets of the MVPT-4 for allowing us to fill the test on the computer and to be able to capture the gaze patterns of the participants. The pattern of eye-gaze fixations and saccades to be used to infer a person's intention or goal within a particular context [21] [22]. Data collected from eye tracking is a record of the position of the eyes in relation to the scene viewed over time. Two essential features relate to fixations (steady gaze on a particular location for some period of time) and saccades (quick eye movements between locations) [21] [23] [24].

In the particular study, we tried to identify gaze patterns that provide valuable information on the participants' during the MVPT-4 test solving: certain patterns where the eye fixates on what the typically developing children are processing and others where the atypically developing children do not hold.

3.3 Research Questions

3.3.1 Research Questions Concerning the MVPT-4

- Are there any differences in MVPT-4 scores between typically and atypically developed children?
- After the intervention period, are there any differences in MVPT-4 scores between the intervention and control group?
- Are there any differences in MVPT-4 scores among CP diagnosis?

3.3.2 Research Questions Concerning Eye-Tracking Data

- Are there any differences in gaze patterns between typically and atypically developed children?
- Are there any differences in gaze patterns and the level of visual attention between baseline and re-test?

4 Results

4.1 Results of the MVPT-4 Test

For the data analysis, we used IBM SPSS 26 software. Due to the non-normal distribution and the small dataset sample size, we used the Wilcoxon signed-rank test (Wilcoxon matched pairs test) to compare the baseline and the re-test values of each group (test and control). The Wilcoxon signed-rank test aims to examine the difference between the available samples. It can be used when two continuous measurements are made on the same group. In these cases, the test examines how much the median of the differences deviates from zero. Small sample size research conducted on the comparative power of the t-test, the Wilcoxon test is appropriate for increased statistical power when the assumption of normality is violated [25]. We applied the Mann-Whitney test to compare the MVPT-4 test results of the two independent groups (intervention and control). The Mann-Whitney U test mainly compares differences between two independent groups when the dependent variable is either ordinal or continuous but not normally distributed [26] [27].

The first research question concerning the MVPT-4 test was: are there any differences in MVPT-4 scores between typically and atypically developed children? Based on the literature, we hypothesised that the visual-perceptual skills of children with cerebral palsy are affected [10] [28] [29] [30]. We have found the same results; the MVPT-4 was used to determine whether children with cerebral palsy demonstrated problems in visual perception on a motor-free visual perception test. Both the baseline and the re-test results showed that children with cerebral palsy attained significantly (p=<,001) lower mean perceptual quotients than typically developed children did (see the visualisation in Fig. 1). The MVPT-4 appears to be a valuable tool for evaluating visual perception in children with cerebral palsy.

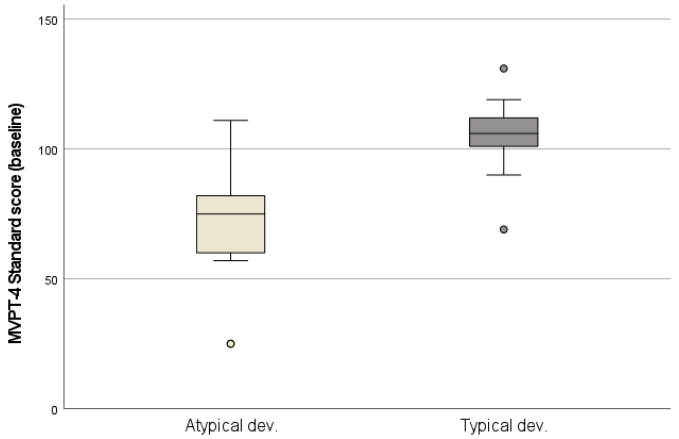

Figure 1
MVPT-4 test results comparison of typically and atypically developing children

Our second research question concerning the MVPT-4 test was: after the intervention period, are there any differences in MVPT-4 scores between the intervention and control group? We found promising tendencies in comparing the difference in baseline and re-test values between the intervention and control groups, but the difference is not statistically significant (Table 1).

Table 1
MVPT-4 test results in both groups at baseline and re-test and the difference of the difference compared the two groups (pre-post) results

		MVPT-4 test standard score at baseline		**MVPT-4 test standard score at re-test**		**MVPT-4 test Standard score difference**
		Count	**Median**	**Count**	**Median**	**Median**
Group	Intervention (test)	9	77	9	101	21,00
	Control	9	72	9	89	21,00
	Sig. Mann-Whitney		0,546		0,222	0,666

One of the possible causes behind the lack of significant differences is an interesting outcome. The difference between baseline and re-test is significant in both groups. It means that the development of visual perceptual skills in this childhood period is very progressive.

Our third research question concerning the MVPT-4 test was: are there any differences in MVPT-4 scores between CP diagnosis? Due to the small sample

size, if we divide it into CP diagnosis we got quite small subgroups; this is why we present only visualisation (fig. 2). On this small sample, we can also confirm that better physical condition supposes better visual perceptual scores. This finding refers to the strong relationship between physical abilities and visual perceptual skills.

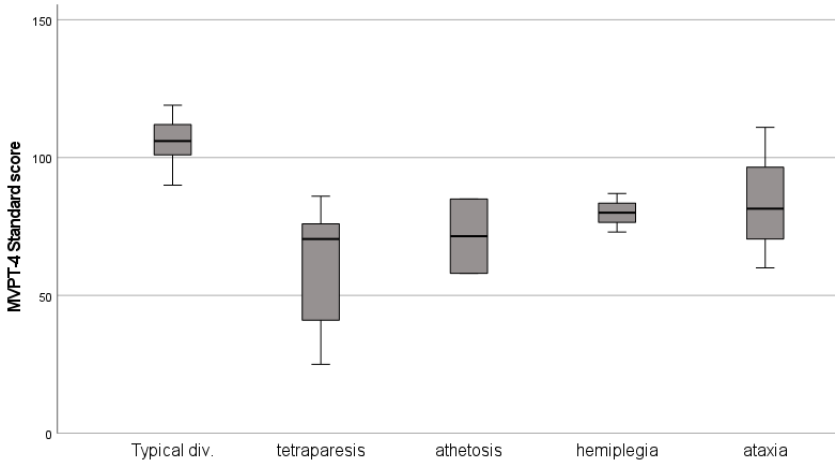

Figure 2

MVPT-4 test results comparison of each CP diagnosis and typically developing participants (N=30)

4.2 Results of the Eye-Tracking Data

We digitalized the test sheets of the MVPT-4 to allow us to fill the test on the computer and to be able to capture gaze patterns. The test does not require a motor response from the participants (motor-free), so digitization should not affect the results. The eye-tracking device has software (Tobii studio) to create the study design and select what outcomes are important for the analysis. This software generates and provides the visualization of the gaze pattern. Raw data such as time of fixation and amount of fixation on any visual subject that appears on the screen can be exported for statistical analysis. Due to a large amount of eye-tracking data, we now provide some promising preliminary results within the present framework, mostly visualization.

We found some changes in the gaze patterns of the atypically developed children. Figure 3 shows the gaze pattern of a typically developing child (fixations and saccades) while solving one of the digitized tasks of MVPT-4.

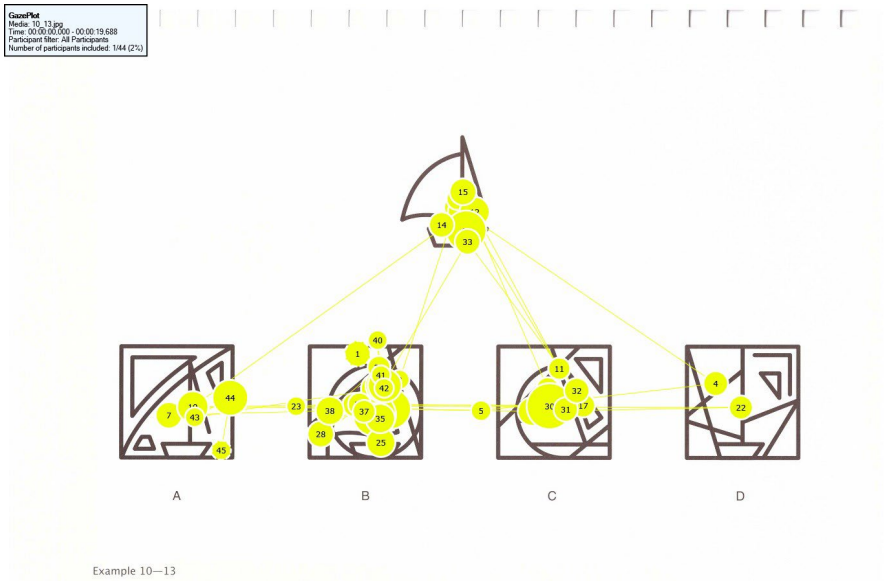

Figure 3
Gaze pattern (fixations and saccades) of a typically developing child

Figure 4 shows the scanning pattern of an athetoid child while solving the same task. The comparison shows that the pattern of a typically developing child is more orderly and purposeful, there are fixations only on subjects (shapes), and the resolution time was less than 10 seconds until the correct answer was announced. In contrast, in the case of an atypically developing child, we see a more unordered pattern, there are more fixations in empty spaces, and it took more than 35 seconds to respond, which was incorrect in the first test.

Figure 5 shows the gaze pattern obtained at the re-test in the same atypically developing child from the intervention group. The comparison shows positive changes, mostly in visual attention. This time he managed to find the correct item in less time than before (27 seconds), and it is clear that the pattern is more organized.

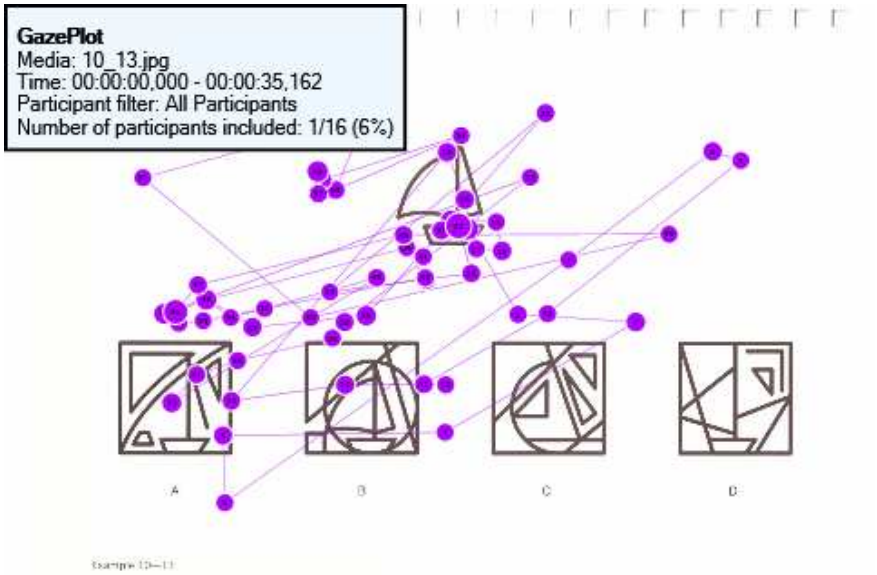

Figure 4
Gaze pattern of an atypically developing child (test group) at baseline measurement

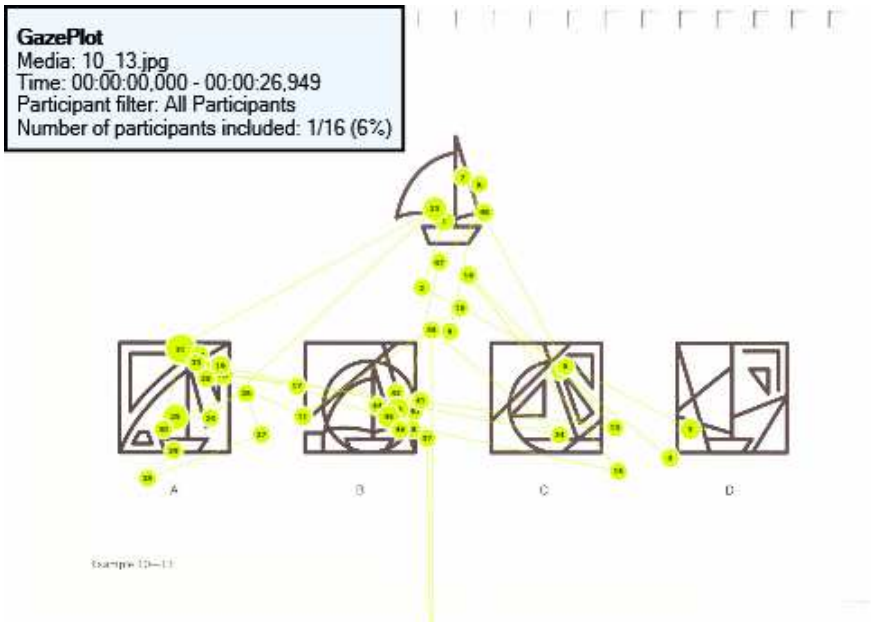

Figure 5
Gaze pattern of an atypically developing child (test group) at re-test after intervention

Conclusions

Cerebral palsy is often associated with cognitive dysfunction that leads to cognitive disabilities, such as visual perceptual skills deficits. Our results confirm this association; the MVPT-4 assessment results showed that children with CP attained significantly (p=<,001) lower mean perceptual quotients than typically developed children did. The MVPT-4 appears to be a valuable tool for evaluating visual perception in children with cerebral palsy.

This study aimed to investigate the long-term effects of the applications we created on the visual perceptual skills of children with Cerebral palsy. To assess the effects, we randomly assigned 18 participants to equally sized intervention (n=9) and control (n=9) groups, and we used the MVPT-4 combined with screen-based eye-tracking. The effect size did not reach a statistically significant level, but the differences are promising; we are suggesting to involve such an educational application in special education programs. The difference between baseline and re-test was significant in both groups (intervention and control), it is suggesting that the development of visual perceptual skills in this childhood period is very progressive.

The preliminary eye-tracking results show that the intervention group's gaze pattern has changed compared to the baseline and the re-test results (e.g., more organized fixations on the subjects), which suggests that positive changes can be recognized in visual attention.

Limitations and Directions for Future Research

The sample size is small, but not unusual in this patient population, even limiting the effect size and the statistical analysis. Another challenge is measuring the application-generated effect on visual perceptual skills because children, especially atypically developing children, get many different kinds of therapies and educational interventions daily. Our data analysis confirmed that this childhood period is very progressive in cognitive and physical development.

We are planning to make a comprehensive eye-tracking data analysis. Based on the results, we would like to create a protocol - for how to apply and implement eye-tracking to motor-free visual perception skills assessment, such as MVPT-4.

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Online Leadership Training in Higher Education Environment

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Abstract: The digitalization of learning, and student-centered and learning outcome-based approaches provide many opportunities for leadership training. This study aims to present a program for the online development of management competencies in a higher education environment by examining aspects of leadership training. It presents the results of the first round of PILOT implementation. A comprehensive overview of the key aspects of leadership development is provided, which lays the foundations for the main directions of online training. The study describes the structure of the online leadership training and the design of its platform. Based on the data from the two-semester program, it examines the feasibility and effectiveness of the courses and the factors that impact them.

Keywords: digitalization; leadership training; leadership competences; online education

1 Introduction

The emergence of online training in the era of information society [1] has been facilitated by the spread of lifelong learning [2], which means that learning becomes a way of life. Pandemic periods in recent years have brought about an explosion in this area, and digital education in the online space has become unavoidable [3]. Global trends in higher education are also increasingly driving towards the rise of online training [4], extending their impact on the transformation of traditional teaching models and practices [5, 6]. The paradigm shift, which replaces teacher-centred education with a student-centred training approach is taking place, and online training are very suitable to facilitate this change. At the same time, traditional educational approaches and methods are no longer exclusive to traditional higher education courses, and their effectiveness can be increased by using digital, e-learning tools or by providing fully online options [7, 8].

On both the supply and demand side, there is a growing demand for digitization and the use of e-learning tools, which has been largely driven by changes in learning, knowledge transfer and acquisition attitudes and skills development at both

individual and group levels [9]. The requirements of e-learning curriculum development must also be strongly met by the faculty. It is important to focus on collaborative learning and to use educational tools effectively [10] by taking advantage of the opportunities offered by modern technologies [11]. Student expectations should be kept in mind, which includes frequent assessment of performance and regular feedback (avoiding an exclusive test- and exam-oriented mentality). In the process of strengthening student-centered education (in contrast to teacher-centered education), the emphasis is shifting from communication to learning and skills development. Online courses are well suited to facilitate this change, as e-learning education is inherently focused on students who are actively involved in an integrated and interactive learning process [12].

In leadership training and in the development of leadership skills, it is especially important to break away from the methods used in traditional, school-based education. This is best achieved through training where the emphasis is on gaining experience and using various tools to create situations that promote the development of leadership skills. Online implementation is also beneficial because it creates a high degree of flexibility and is thus more time-efficient than face-to-face training. In addition, interactivity can be easily ensured and learning materials can be updated more flexibly. Curriculum can be viewed and reviewed any time and any number of times, and feedback can be more frequent and immediate.

In leadership training, we can find several online offers, the number of which has further increased because of the pandemic. There are many examples of this type of training, both domestically and internationally. On the one hand, it is worth browsing at different online educational platforms (e.g., Coursera, Udemy, edX, Fiverr Learn) where they offer plenty of online courses, including developing leadership skills [13, 14]. There are also companies that offer training specifically on a business basis, where online management training is also part of the offer (e.g. Plurasight) [15]. We can also find organizations that focus entirely on leadership and offer training solutions in different areas (e.g. Center for Creative Leadership) [16]. And, of course, higher education institutions are also present in the leadership training market, with a number of online courses (e.g. Stanford University) [17].

The online leadership training developed at the University of Dunaújváros enriches the course offerings organized by higher education institutions. A two-semester course covering special leadership topics was developed and implemented on an online platform dedicated to this purpose, which is available to students in both Hungarian and English. In our study, we present the research evaluating our training that develops leadership competencies in an online, higher education environment, focusing on course completion and results of the training.

2 Development of Online Leadership Training on a Higher Education Platform

In order to become a successful leader, it is necessary to develop basic leadership skills and abilities. Based on the managerial functions and tasks, the most common development needs from managers – summarizing the experiences of three internationally recognized training companies – can be grouped around the following topics and issues:

1) leadership roles
2) setting priorities
3) delegation process
4) giving / receiving feedback, evaluation
5) managing groups, leading discussions. [18]

1) To a certain extent, every manager must also be a professional, which decreases with the level of hierarchy and the number of subordinates. In order for a leader to be recognized, he or she must also have the expertise to intervene in supportive or decisive situations that may arise from time to time. A successful leader is also a coach. A coach is characterized by personal qualities such as charisma and social competence, as well as theoretical and practical knowledge in his or her field. In addition, certain administrative tasks also need to be performed. No manager can avoid reporting and budgeting, personnel administration, and future planning. A well-functioning administration is an essential prerequisite for effective corporate work.

2) A leader faces many tasks on a daily basis. For an organization to be dynamically sustainable and profitable, it is important for a leader to make appropriate decisions in various areas, like which tasks are urgent or important, and prioritizing among the tasks and problems that arise. For this, the trainings typically use the Eisenhower principle (eisenhower.me), which helps organize the tasks that arise in the matrix of importance/urgency.

3) When delegating, the most difficult questions for the leader are what and to whom. That is: What is the task that you can responsibly delegate to the right person? Who is the right person? Prioritizing helps to delegate tasks. The urgent and important task is performed by the manager (or a specialist with the direct assistance of the manager). Non-urgent or non-important tasks can be delegated, while non-urgent-non-important tasks can be at the bottom of the list. Another difficult question is who to delegate to. We are not only talking about the task, but also about the development of the subordinates. The manager must find the right management style to fit the subordinate during delegation in order to complete the task in the right way [19]. The leadership style chosen then depends on the maturity (motivation, confidence, personal commitment) and level of development (professional competence) of the employee.

4) When giving and receiving feedback, it is especially important for the leader to be able to be “here and now” in the interaction. This type of interaction accompanies the day-to-day work of the leader from assigning tasks to evaluations. There are a number of rules for feedback that we do not disclose now, but there is a well-applied model called Nonviolent Communication [20]. This model supports the leader in being able to share his perceptions clearly with his environment, providing a basis for formulating clear feedback (observation, feeling, demand, request).

5) Based on their motivation and performance, members of a team can be divided into three types: average/medium, above-average, and below average. It should be added that new members in the team tend to adjust to the average or worse, to the least working colleagues, depending on what they consider to be the norm within the group. The steps for managing a group can be summarized as follows:

1. Introduction of an "OK" - "not OK" performance evaluation
2. Clear and transparent information about the team's goals and expectations for the team
3. Clear and transparent information on specific expectations for each employee
4. Regular feedback to the team (both positive and negative feedback)
5. Regular individual feedback (both positive and negative feedback)
6. Managing the personal development of each employee through structured discussions
7. Accurate goal tracking and management of each employee's activities through structured discussions
8. Ongoing conflict resolution and problem-solving competence with structured discussions. [21]

When conducting discussions, the leader must ensure that they create the right atmosphere, are factual, and constantly make sure that they are moving towards a mutually acceptable solution.

There is a positive relationship between managerial success, efficiency, and organizational success [22, 23]. Leadership success is inconceivable without identifying and developing the competencies required for it, which is supported by numerous theoretical and empirical studies [24, 25]. The development of leadership competencies within a traditional training framework can only be achieved to a limited extent, focusing on certain elements. At the same time, digital, online training interfaces provide an effective solution to leadership development through the application of a learning outcomes-based approach.

2.1 Programs for Online Leadership Training

The online leadership training was developed at the University of Dunaújváros in two phases after reviewing the literature background and evaluating domestic and international good practices. Between 2018 and 2019, we focused on developing the first part of the training and creating an online platform. In addition to the development, several other extracurricular elements were implemented during this phase with the support of the Pallas Athena Domus Educationis (PADE) Foundation, which ensured the quality control of the developed curricula and the reward of the instructors and researchers involved in the development. During these two years, in addition to the development of the curriculum structure and the development of the first online learning material package, the online platform got also developed.

The second phase took place in 2021-2022. The "University Network for Sustainable Development" tender announced within the framework of the Horizontal Program of the National Bank of Hungary supported the second and final phase of the development: new online learning materials were developed, and we presented our new and relevant developments at conferences and workshops organized by research groups. This project, similarly to the PADE project, supported the process with a number of other activities, notably high-volume library development, which focused on our leadership training program in addition to general business administration and management courses.

The content developed during the two phases was subject to continuous testing. In addition to proofreading the professional materials and testing the online interface, we ran a PILOT program with the involvement of our students to see how the curriculum and platform work and to eliminate any problems. Our long-term goal is to accredit a specialized continuous education program that uses online content and that provides future leaders a professional training targeting the concept of sustainable economics.

2.2 Training Structure and Content

The planned specialized training will be based on 2/3 online/digital and 1/3 traditional face-to-face education. The present study primarily aims to present the structure of the online content, as well as to summarize the results from preliminary testing and to draw conclusions. The first semester of the specialized training offers courses on the individual and social aspects of economic development and sustainability. The second semester focuses on sustainable economics and on the future challenges of leaders. The learning materials are available in both English and Hungarian. The structure of the online part of the training is as follows.

Semester 1	Semester 2
1. Development of professional competences	1. Platform Economy and Sharing Economy
2. Mastering leadership skills	2. Globalization, knowledge management, information management
3. Time management	3. Cryptocurrency and the virtual world
4. Presentation technique	4. HR in the world of robots
5. Smart solutions and technologies in the local sphere	5. Health economics
6. Project management techniques	6. Consumer protection, consumer awareness, rights and obligations – in the 21st Century, where information is the "new oil"
7. Economic modelling, world of business processes	
8. The role of virtual economy and digital technologies in the economy	

3 Research and Methodology

The aim of the PILOT program is to examine the completion and effectiveness of the courses and to detect any problems in the digitized content by testing the online interface of the training. In the testing of the curricula, we involved students of the University of Dunaújváros, primarily students in the majors supervised by the Institute of Social Sciences.

The two-semester extracurricular leadership training program was supported by curriculum development instructors. We provided consultation opportunity for all registered students. In addition, in each of the two semesters, we organized special workshops and conferences. At the conferences, curriculum developers were given the opportunity to present the content elements of the courses and to explain the scientific contexts of the curriculum development. Reviewers of the learning materials also participated in the conferences and drew attention to the further development possibilities of the leadership training.

A total of 188 students and 14 curriculum development instructors participated in our study. The study was based on specific analyses of the data stored in the university's online training platform, in the Moodle system database. Our research is exploratory and open-ended, as it does not test predetermined hypotheses. By analyzing the data related to course completions and their results using statistical methods, we sought to find out which factors might affect the effectiveness of our online leadership training.

4 Results and Discussion

Regarding the testing of the curricula of the first semester, we found that 50 registered students completed 198 courses, while in the second semester 133 students achieved 221 course completions. Based on the data, it can be stated that each student generally took several courses and completed them online. The distribution of course completions is illustrated in Figure 1.

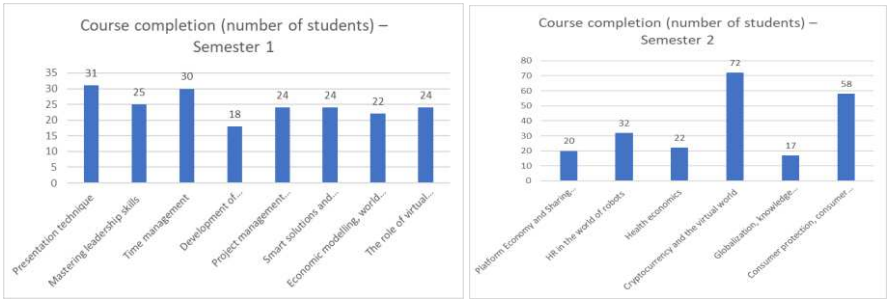

Figure 1
Distribution of course completions by course, per semester

While the distribution of course completion can be considered even in the first semester, we can see that in the second semester the courses related to Cryptocurrency and Consumer protection ended the semester with an extremely high number of completions. In addition, it should be mentioned that the system documented an additional 150 students who enrolled in the system, used the learning materials only once, but did not complete a single course. Moreover, there are a number of students who tried to complete the courses but were unsuccessful. The distribution of unsuccessful completions is illustrated in Figure 2.

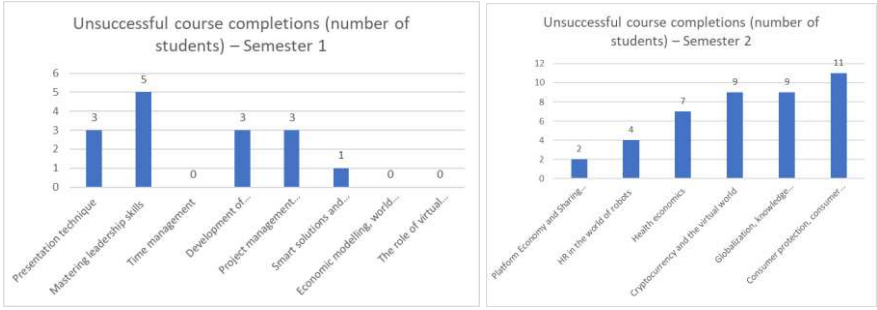

Figure 2
Distribution of unsuccessful course completions by course, per semester

It can be seen that the distribution of unsuccessful attempts is in line with the proportion of students enrolled and successfully completed, with an even distribution. However, the failure rate of one course is much higher than the others.

In the course entitled Globalization, knowledge management, information management, there were only 17 successful course completions and 9 unsuccessful attempts.

Students who successfully completed the courses generally achieved high scores. The structure of the courses is standardized in the whole online leadership training program. There are short quizzes and assignments in the chapters and assessment tests at the end of each chapter, which prepare students for the final test at the end of the course. Figure 6 illustrates the average scores for each course (evaluating all tasks in the entire course) in a percentage form.

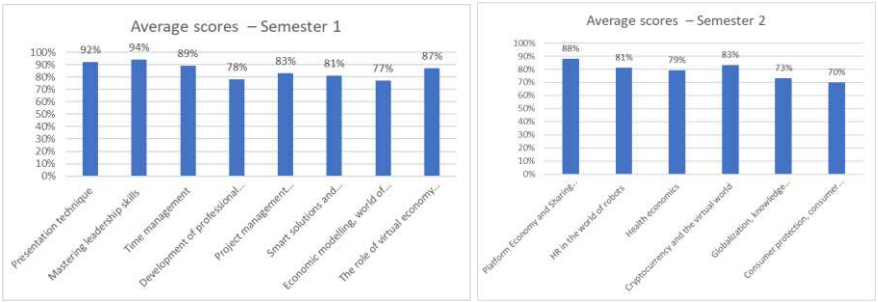

Figure 3

Average scores of course completions, per semester

Based on the results obtained in the first semester (see Figure 3), it can be stated that the students managed to complete the course Mastering leadership skills with the highest score, with a very high 94% grading. The completion of the Presentation technique course was not much lower than this, with a result of 92%. These two course scores, which are above 90% on average, are presumably due to the fact that in the traditional university curriculum of the students we can find subjects with similar topics, even if they have different content, so the participants already had some kind of pre-qualification.

Most of the first semester courses ended with an average score of between 80 and 90 percent, which can be classified as good in the traditional evaluation scheme. These, i.e. Time management, Project management techniques, Smart solutions and technologies in the local sphere, and The role of virtual economy and digital technologies in the economy, aim to transfer focused knowledge, making them presumably easier to accomplish. While the Development of professional competences and the Economic modelling, world of business processes courses, which have average scores of between 70 and 80%, are rather multidisciplinary and professional courses, which presumably require more preparation from students.

Looking at the scores of the courses of the second semester, it can be said that an excellent (above 90%) average score was not obtained in any of the courses. Half of the courses (Platform Economy and Sharing Economy; Cryptocurrency and the

virtual world; HR in the world of robots) got completed with average scores between 80 and 90%. The other half (Globalization, knowledge management, information management; Health economics; Consumer protection, consumer awareness, rights and obligations – in the 21st Century, where information is the "new oil"), had course completion scores between 70% and 80%. The courses of the second semester focused on more specialized topics related to sustainable economics and economic megatrends, the acquisition of which would probably have required more attention and more time on the part of the students.

We also looked at how educational material usage within each course affects the effectiveness of completing the final tests. The impact of educational material usage on the average test completion results is illustrated in Figure 4.

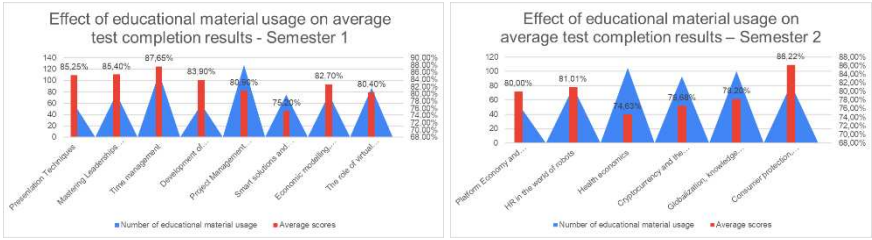

Figure 4

Effect of educational material usage on average test completion results, per semester

Regarding the courses in the first semester, it can be said that in the case of courses where the educational material was used several times, the results were generally better. This is particularly the case for the courses in Presentation techniques, Mastering leadership skills, Time management and Development of professional competences, all of which had an educational material usage over 25, resulting in nearly 85% or more in average test completion results. The lowest educational material usage (less than 15) was for the course Smart solutions and technologies in the local sphere and it also had the lowest test completion results (75.20%).

Regarding the courses in the second semester, this kind of correlation could no longer be experienced. However, it can also be stated here that in the case of the two highest test completion results – Consumer protection, consumer awareness, rights and obligations – in the 21st Century, where information is the "new oil" and HR in the world of robots courses – in both cases the number of educational material usage was over 40, resulting in an average test completion score above 80%.

We also looked at whether the time spent completing the final tests affected the results achieved. That is, for courses where more time is spent completing the tests, the results improved, or vice versa, are results lower for tests that require more time and are presumably more difficult? The effect of the time spent completing the tests on the average scores is illustrated in Figure 5.

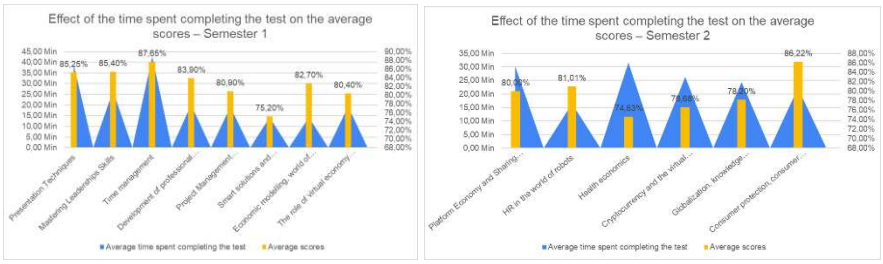

Figure 5

Effect of the time spent completing tests on the average scores, per semester

Based on the statistics of the courses of the first semester, it can be said that the average scores of the final tests were the highest in those three courses (Presentation techniques, Mastering leadership skills, Time management) (87.65%, 85.40%, 85.25% respectively), where students spent the highest time completing the tests on average. In the case of the Smart solutions and technologies in the local sphere course, where students spent the lowest time – less than 15 minutes on average – completing the final test, had the lowest average test score (75.20%).

Based on the statistics of the second semester courses, no such type of correlation was observed. In addition, we examined the relationship between the time spent completing the final tests in these courses and their scores with respect to course-completing students. Figure 6 shows the relevant statistics for the Cryptocurrency and the virtual world course, which had the highest student number. Based on the data, it can be said that students who took more time to complete the final test generally completed it with good results.

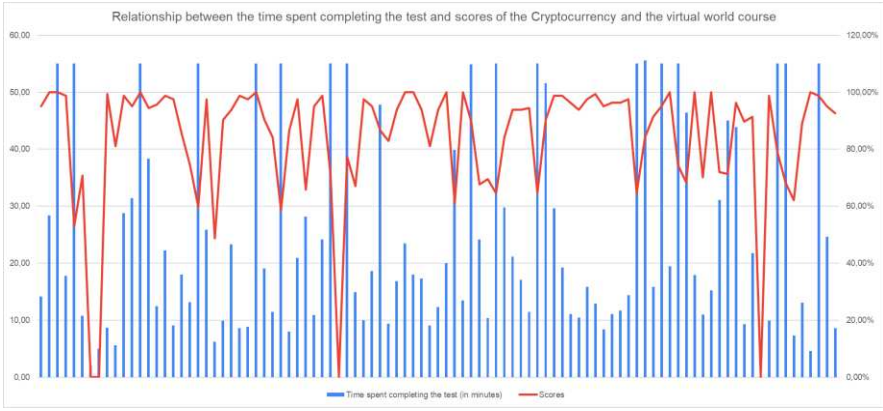

Figure 6

Effect of time spent completing the final test on the average scores, for the Cryptocurrency and the virtual world course

In addition to the results achieved, the course statistics also illustrate well that those students who were committed to mastering each course material and completed the courses were able to achieve very high results with sufficient practice. The data of the short quizzes and assessment tests related to each chapter of the courses show that these students kept retaking these tests until they achieved the optimal score – typically 100%, and this helped them to prepare for the final test, which could only be taken once.

Conclusions

The redesign of the courses according to the opinions of the reviewers, the consistency of the tests and the large number of interactive elements greatly contributed to the achievements and success of the online leadership training program presented in our study. Our research highlighted two issues. On the one hand, we have to deal with students who register for the training but do not complete any courses. We need to find a way to retain those who have registered for the training. One solution is to provide consultation opportunities (preferably online) or to further develop the online platform and rethink the interactive elements of the courses, by applying gamification for instance.

Moreover, the online training program has courses where the registered / completed / unsuccessful ratio is exceptionally high in favor of unsuccessful course completion. In these cases, it is important to re-validate the course completion criteria based on the requirements of the other courses in the program. It is essential to revise the content elements of the courses and to comply with the accreditation requirements to be able to authorize the projected specialized continuous education program.

The student-centered education implemented on the online platform is particularly suitable for developing competencies that participants will actually need in their work. Of course, this requires learning materials and content that provide up-to-date knowledge, and that the focus should be on problem-solving, collaborative learning (see collaborative methods). The digitization of learning, with its audiovisual and interactive tools, increases the acceptance and retention rates of information available through traditional teaching methods (see the learning pyramid) [26] and exploits the potential of experiential learning [27] [28].

In addition to the traditional course offerings of higher education institutions, there is a growing demand for the development of extracurricular, short-term educational programs. These training programs require a specific approach compared to traditional higher education methods, both in terms of the courses offered and the learning materials provided, as well as developing an interactive and knowledge-sharing learning environment. As we have presented in our study through the examination of an online leadership training program, digital and e-learning solutions provide adequate flexibility and educational learning efficiencies for these training services.

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Gaps and Bridges between Future Managers and IT People

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Abstract: Today's HR tendencies face many challenges. One of them is the interaction between managers and IT people. Our evidence-based study describes the psychological background of that misunderstanding. The research shows that students of different faculties have the same attribution year by year (between 2018-2020, three academic years) but they differ significantly by faculty. The total sample was examined (n=2305) and we found differences in students' personalities, i.e. their level of extraversion which could be the basics of all interpersonal conflicts. We propose that they couldn't handle workplace situations appropriately because they are significantly different in their emotional intelligence measured with Bar-On's EQ-i and they adapt to stressful situations differently based on their diverse coping skills. HR solutions could be developed based on these findings in the form of training or organizational policies.

Keywords: HR; digital generation; personality; emotional intelligence; coping

1 Introduction

Basic characteristics of human nature and behavior are frequently in conflict with organizational and business requirements, even from the point of view of competitiveness. The same applies to the field of cooperation and knowledge-sharing. Success of corporate cooperation, teamwork and information flow between organizational units depends on the effectiveness of the communication. In the world of HR, there must be new and non-used solutions to apply [1].

The communication between IT People and managers become a new profession. In our research we are looking for the answer, which psychological factors could cause huge differences between these two groups. We suppose that young engineers and economists have the same generational features; if we find their differences, we can work on programs focusing on the difficulties of communication. For this research program, we examined first-year students of the Budapest University of Technology (BME in Hungarian), who learn on economy major (future manager), and electrical engineering major, also on information technology major (future IT-people). Even though the students, who were selected in the sample, learn at the same university, probably in the first semester their personality traits gain better. Our survey, beyond the description of differences between the two groups, can describe and introduce the future managers and IT People preparing for the labor market. All that contributes to understand those complex corporate relations, where differences between managers and IT-people are made even more difficult by age differences.

Nowadays, a rather live and unresolved issue is how to deal with the requirements and labor market needs of one of the youngest age groups, i.e., the digital (Y, Z, Alpha) Generations [2-3]. Meretei [4] assumed that on the market working generations are differently satisfied with their job, represent various work ethics, do not take same responsibility and think diversely about work-life balance. These generations also differ in a way how they get their job done and how confidently they use technology and move in the virtual world [5]. Therefore, current HR-tendencies should be changed 1) to enable a company to meet new requirements of the new generation, 2) to ensure that they fit in as active and productive members of the organization, 3) to develop quality communication and real collaboration between the representatives of different disciplines.

2 Literature Review

There are several approaches which define the term of generation describing it as a connected group sharing social and historical experiences [6], or sharing beliefs and behaviors due to their history [7], or as group of people who build a cohort and gain the same experiences [8]. Mannheim [6] was one of the early pioneers in generational research who described generations based on people's collective experiences. Based on these we can assume that the main characteristics of a generation are defined by age groups, common location of members and their experienced social and historical processes on these locations [6]. Not just birth and social, historical experiences are important by defining generations, but Howe and Strauss [7] emphasized also the thoughts and feelings of one person about how he views himself and his generational group. According to Howe and Strauss [7] the members of a generation share the feeling of belonging, the same beliefs and also some common behaviors above their collective historical experiences.

Törőcsik et al. [8] approached generations through the lenses of cohort theory. In this sense people born in the same year belong to the same cohort [8].

Beyond age and historical experiences mostly technical competencies describe the differences between generations. Thereof, Törőcsik et al. [8] emphasized innovational aspect in generational theories and in the same time digital innovation brought a new approach in everyday life and research, namely the digital generation. Increasing time spent on the internet and high use of technology characterize the digital youth, including Generation Y, Z and the Alpha generation. Prensky [9] shaped the terms of digital natives and digital immigrants. He described digital natives as people born into the digital word, being surrounded by technology from the first moments of their life. They are mostly young people who communicate, socialize and also learn on the internet [10]. According to Prensky's theory [9] digital natives are familiar with online world and the newest technologies. They are used to quick information sharing, downloading and searching. Furthermore, this young generation choose usually the instant way, looking to graphics rather than reading, expecting gratification and rewards right after a task is delivered or connecting to each other, i.e., networking all day from wherever they are. With Prensky's word they are "native speakers of the digital language of computers, video games and the internet" [9, p. 1]. The opposite of digital native is called digital immigrant. They are somehow old-fashioned from the perspective of the youth [9].

White and Le Cornu [11] revised the terms of Prensky and suggested a new typology. They made not a strict distinction between digital residents and digital visitors like Prensky made earlier between digital natives and immigrants. They considered these two clusters as two ends of a continuum which describes technology use depending on individual motivation and context, not just from age. Digital visitors are people who use internet and applications as tools for their goals, after they reached the goal, they leave the internet and live their life offline. While in contrast digital residents use these tools to create a place where they can approach each other and share information about life and work permanently. They prefer to live online and be a member of virtual communities. They enjoy being online and visible, forming their digital identities [11].

Buda [12] developed a more sophisticated characterization for the information society in our digital world. In his view people who do not use or not even possess digital devices are digital eremites. Digital explorers already have digital devices but are still learning how to use them and prefer simpler devices. Digital nomads use both the internet and computer but not so confidently yet. They consume digital written content and prefer familiar websites and platforms. Digital wanderers usually use the internet and digital devices, but still have challenges in some aspects. The modern citizens of information society are the digital settlers who consume and create content, use digital communication, social media and platforms for banking or booking too. Finally, the highest digitalization is reached by digital conquerors. They use the internet as exclusive source of information,

are always available and online. Digital world and technology are essential in their life [12, 13].

University students also can be characterized nowadays as digital natives, digital residents and digital settlers or digital conquerors. Because they are part of the digital generations, generation Y or Z, and are also experts in technology. They use different media platforms to gain more information, preferably in the form of pictures and videos. They are used to innovative technologies and devices and they operate with them in schools and work [14, 15]. Although they represent the digital generation, they differ in career aspirations, habits and personality. This conclusion can be drawn from analyzing the characteristics of university students from different faculties.

While examining educational orientations Morstain and Smart [16] found that between members of different faculties can be found some personality differences too. Social faculty members seemed to be more independent, valuing freedom and unstructured courses where they can set their goals. Besides this the faculty also enabled participation in decision making and teaching-learning arrangements and secured individual-centered functioning. In comparison Realistic and Investigative faculty seemed to prefer structure and pragmatical behavior and emphasize evaluation in the form of grades. They expected students to have clear, rational goals and gain practical experiences by using their scientific knowledge and technical skills. In both cases could be drawn a parallel between the personality of students and the previously mentioned characteristics of faculties [16].

Personality dimensions gave a great basis to comparison of university students. For this reason, Kline and Lapham [17] also examined personality differences among university students and searched for factors which can determine academic success and occupational choice. In the conscientiousness and conformity factors scientist and engineers scored significantly higher than other faculties, and engineers scored higher on the tough-mindedness factor too [17]. Rubinstein [18] also analyzed the differences between university students of different faculties and found that according to the Big Five theory law students are significantly more neurotic than other science groups. Whereas natural science students seemed to be the most agreeable in this comparison [18].

After the success of personality research of different faculties Sánchez-Ruiz, Pérez-González and Petrides [19] extended research to trait emotional intelligence assuming differences between the faculty members of social sciences, technical studies, natural sciences, art and humanities. Social science and art students proved higher emotionality than technical students. Additionally, art students also scored higher in well-being and global trait emotional intelligence, and lower than other faculties in self-control. This latter result might reflect just their perception of their ability of emotion regulation and stress-management [19]. In contrast, Kafetsios and his collegues [20] found supporting evidence that science students have higher trait emotional intelligence than social science students reported by

their self-assessment. They differed in factors of adaptability, positivity in mood, self and social awareness, self-management and social skills. Supporting the fact that science students have higher emotional stability due to their emotional self-efficacy. While measuring ability based emotional intelligence, social science students seemed to perform more emotional intelligence than science and business students [20]. Later, Pertegal-Felices, Castejón-Costa and Jimeno-Morenilla [21] conducted research to describe differences between teaching and computer engineering students and professionals and to determine the most important competencies for these professions. By the analysis of emotional intelligence, it was proven that teacher training students have higher emotional intelligence, extroversion and agreeableness than engineering students and they have also differences in their personality profiles. Interpersonal skills and mood were the most important factors for teachers, while conscientiousness, stress management, adaptability and interpersonal skills belonged to the engineers' professional profile. Although there were differences between the professional profiles, both professional groups confirmed the importance of personal, social and emotional skills [21]. Differing important personal competencies also occurred when Ballesteros-Sánchez, Ortiz-Marcos and Rodríguez-Rivero [22] investigated the competencies of engineering graduates and practicing project managers. Although engineers obtain professional knowledge at the university, they have to use specific skills when becoming a manager or a project manager on the labor market. The personal competency units were for both groups emotional management, self-belief, commitment, communication, problem-management, resources management, team leadership and professionalism. Project managers were better in all competency units, but just in conflict management, team leadership, communication, emotional management and professionalism differed significantly from engineering graduates. Besides the differences, these groups share some similarities too. Their lowest competencies were communication and resource management, meaning they face challenges when managing their own resources. Therefore, graduates have to develop these skills and focus on team competencies and social awareness when becoming a project manager [22].

Furthermore, the last few years of pandemic verified the importance of personality factors in the hybrid and mostly digital world. Especially, the factors which help to tackle with uncertainty and unexpected changes, like positive psychological resources. Bernabe-Valero, Melero-Fuentes, De Lima Argimon and Gerbino [23] found evidence that some personality factors influence our experiences negatively. Their results showed that emotionally unstable people suffered more under the period of lockdown because they are less satisfied with their relationships, might suffer from depression, fear or social rejection. While conscientiousness helped people to be cautious and aware of the steps which kept virus far from them. Gratitude, purpose in life and religiosity were also influencing the experiences during the pandemic. Gratitude secured a positive effect and ensured positive effective experience when facing adversity. Purpose in life also showed a positive association with positive effect through finding new meaning in life and so

lessening the negative effect of the pandemic [23]. Another research emphasized the role of resilience in navigation through stressful times. Ang, Shorey, Lopez, Chew and Lau [24] conducted interviews with university students and their results confirmed that resilience can help in uncertainty and changing times. Their primer source of resilience were social connections which could have been maintained through the internet and applications [24]. This means that digital generation survived this challenging time through utilization of technology and their advanced skills in the online world, respectively to their personal skills.

To summarize

3 Data and Methodology

3.1 Methodology

The present paper is a part of a longitudinal descriptive survey started in 2018 at the Budapest University of Technology and Economics. The study was conducted according to the guidelines of the Hungarian Committee of Psychological Research and approved by the Ethics Committee (approval code: 81). We gather data automatically from the Neptune system about the socioeconomic status and university entrance scores and within we asked first-semester students to fulfill a long online questionnaire about psychological characteristics with a special focus on their positive psychological attributes. The measurement tools were the Hungarian versions of the following inventories, shared via the Neptune system directly to the first-year students in the middle of their first semester (November of the given year). The questionnaires were presented to the respondents in the structure described below. After the 1-month data collection period (which ended before the first examination period), we downloaded the answers from Neptune.

To get a picture of students' personalities, we used the Eysenck Personality Questionnaire (EPI), a 58-item test where students have to decide whether an item is true or false in their case [25-27]. Based on Eysenck's theory personality differs in three main dimensions: extraversion (i.e. the tendency to seek peers, activity, and relationships – in the form of higher scores on the scale) vs. introversion (i.e. the tendency to stay alone – lower scores on the scale); neuroticism (i.e. emotional instability – in the form of lower cores on the scale) vs. emotional stability (i.e. the person is not influenced by emotional cues – higher scores on the scale); psychoticism (i.e. how much a person is aggressive, masculine and nonconform – higher scores means higher level of psychoticism). The test has internationally good psychometric properties [28].

As a holistic tool to describe students' emotional profiles, we used the Bar-On Emotional Intelligence Inventory [29-30]. The test has acceptable psychometric properties based on international validity measures [27; 29]. The Hungarian version contains 121 items, each with a 5-point Likert scale. The higher score a person on the scale has the higher is the mentioned competence he or she owns. Based on Bar-On's theory of EI, the inventory measures 15 subscales in 5 factors [31; 32, p.21.]:

Table 1
Description of the EQ-i scales [32]

EQ-I SCALES	**The EI Competencies and Skills Assessed by Each Scale**
Intrapersonal	**Self-awareness and self-expression:**
Self-Regard	To accurately perceive, understand and accept oneself.
Emotional Self-Awareness	To be aware of and understand one's emotions.
Assertiveness	To express one's emotions and oneself.
Independence	To be free of emotional dependency on others.
Self-Actualization	To strive to achieve personal goal, actualize one's potential.
Interpersonal	**Social awareness and interpersonal relationship:**
Empathy	To be aware of and understand how others feel.
Social Responsibility	To identify with one's social group, cooperate with others.
Interpersonal Relationship	To establish mutually satisfying relationships.
Stress Management	**Emotional management and regulation:**
Stress Tolerance	To effectively and constructively manage emotions.
Impulse Control	To effectively and constructively control emotions.
Adaptability	**Change management:**
Reality-Testing	To objectively validate one's feelings and thinking.
Flexibility	To adapt and adjust one's feelings to new situations.
Problem-Solving	To effectively solve personal and interpersonal problems.
General Mood	**Self-motivation:**
Optimism	To be positive and look at the brighter side of life.
Happiness	To feel content with oneself, others and life in general.

With the focus on positive source competencies, we used the PERMA Profiler [33]. This is the first holistic measurement tool of well-being with acceptable psychometric attributes. The Hungarian version contains 23 items with 10-point Likert scales. The final structure has 7 scales, five from the original PERMA structure: positive emotion (P), engagement (E), positive relationship (R), meaning or purpose in life (M), accomplishment (A), and two new factors of the refined model: negative emotion, physical health where higher scores mean the higher level of the phenomena. With one 1 item the profiler gives a score of people's self report of happiness and loneliness [33].

To measure the behavioral aspect of dealing with stressful situations we used a questionnaire developed in Hungary by Oláh [34-35]. The coping preference test contains 80 items about behaviors in stressful situations with a 4-point Likert scale. The test gives a preference profile of 8 coping strategies as problem-focused ones (e.g. problem-focused reaction or support-seeking behaviors) and emotion-focused ones (e.g. impulse control, emotion-focused actions, acting out, self-punishment, acquiescence, and attention diversion). Even higher the score on a scale is, the often the person use the mentioned coping style.

To measure the mental and psychological aspects of coping we used a test of the same author [36-39]. The Psychological Immune System Inventory contains 80 items with a 4-point Likert scale. The higher score on the scale means the higher level of the competence. The profile shows 16 subscales in three systems:

Table 2

Oláh's [36-37] model of psychological immune system (PI) that corporates cognitive, behavioral and trait attributes

PI SCALES	**The PI Competencies and Skills Assessed by Each Scale**
Approach-belief subsystem	**Helps people to adjust to their environment.**
positive thinking	Optimistic beliefs that current events are proceeding towards ideal situations.
sense of control	One's capacity to control one's own emotions.
sense of coherence	One's ability to harmonize thoughts, emotions, behaviors, and lifestyle.
feeling of growth	One's feeling of continuous self-development and achievement.
challenge seeking	One's ability to stay open for novelty and development.
social source monitoring	One's ability to selectively observe and use socio-environmental cues and information.
goal orientation	The ability to stay focused on goals.
Monitoring-creating-executing subsystem	**Helps to explore physical, social, and interpersonal sources that can help during the coping for finding out new challenges.**
self-efficiency	One's degree of positive and realistic self-estimation, self-esteem, and ability to feel proud.
creativity	One's degree of inventiveness, ingenuity, or creativity in developing, managing, and restructuring plans.
mobilizing skills	One's ability to strengthen belief, achieving goals, and selecting appropriate behaviors.
social source founding skills	One's ability to make connections, gain social capital, and collaborate.
learned optimism	One's ability to generate new ideas and alternative possibilities.

Self-regulating subsystem	**Helps to stabilize for the long-term persistency of the first two subsystems.**
mindfulness or synchronization skill	One's capacity to perceive environmental changes while attending to personal activities.
control of emotions	One's ability to transform negative emotions constructively.
impulse control	One's capacity to control anger or constructively apply it.
irritability-control	One's ability to control personal notions, rationalize and choose the appropriate behavior.

3.2 Data and Sample

The data included students from three years, who completed the questionnaire in the fall semesters of 2018/19/1, 2019/20/1, 2020/21/1. The participants came from two faculties of Budapest University of Technology and Economics: Faculty of Economics and Social Sciences (later referred as the faculty of future managers) and Faculty of Electrical Engineering and Informatics (later referred as the faculty of future IT people).

In case of Sample 1, 416 students completed the survey in 2018/19/1, of which 177 were manager students and 239 were IT students. Their average age, regarding that most of them attended their first semester, was 19.4 years. Altogether, 264 men and 152 women filled out our survey. After grouping by faculty, 114 women and 63 men (64.4% women) at manager faculty and 38 women and 201 men (15.9% women) at IT faculty answered.

Participants os Sample 2, who completed the survey in the fall of 2019/20/1, have similar descriptive statistical characteristics, although the sample has a much larger number of items. 772 students completed the psychological questionnaires, of which 341 were students of manager faculty and 431 of IT faculty. Their average age was also 19.4 years. The proportion of the sexes showed a similar distribution, approximately twice as many men as women completed the questionnaires. The entire data set included data from 259 women and 513 men. 197 (57.8%) of the manager respondents were girls and only 62 (14.4%) of the IT-people respondents were female.

Data of Sample 3 comes from the 2020/21 academic year, the number of respondents increased again compared to previous years. This year 1 117 students completed the questionnaire, 475 students of manager faculty and 642 students of IT faculty. We gender data are missing.

The inventories were administrated as their protocols assess [25-27, 29-30, 33, 34, 36]. In the following parts, we only show the calculated points, subscales, and scales of the psychological attributes of the students. For data calculation and analysis, we used the SPSS statistical program to get the 58 final psychological variables from the 362 items pro person.

4 Results

The main aim of the research was to investigate the psychological factors that differ between the two faculties. In all three years, we examined the normality of the data sets by faculty, from which at least one faculty showed not normal distribution. Therefore, the independent sample nonparametric analysis was performed, using the Mann-Whitney test, and then the results were analyzed at a significance level of 0.05. An analysis of the 58 factors was performed for every year, and then a conclusion was drawn comparing the results of the three years. These are the 4 factors of Eysenck's Personality Inventory (EPI), the 20 factors of Bar-On's emotional intelligence inventory (EQ-i), the 7 factors of PERMA Profiler, the 19 factors of the Psychological Immune System Inventory, and the 8 other factors describing coping preferences.

The factors in which we rejected the null hypothesis in all three years, i.e., we found a significant difference between the mean values of the psychological results of the two faculties, are listed below. Managers' and IT people's characteristics showed significant differences on 18 such factors. From them nearly half of the factors represent the psychological immune system, 30% the EQ-i questionnaire, 22% the PERMA Profiles, and just one the coping strategies and one the personality measured by EPI. In Table 3 we can see the averages of factors where we found significant differences in every year from 2018 to 2020.

Table 3

Cumulated differences between managers and IT people, scores given in percentages (n=2305)

Psychological factor	Average for managers (n = 993)	Average for IT-people (n = 1312)
EPI extraversion	60.95	56.86
EQ-i independence	55.79	59.32
EQ-i interpersonal scale	72.60	66.33
EQ-i empathy	72.70	69.25
EQ-i social responsibility	72.27	67.48
EQ-i interpersonal relationship	72.47	69.40
EQ-i general mood scale	72.83	67.48
PERMA positive emotions	71.12	66.66
PERMA happiness	74.25	61.81
PI approach – belief subsystem	65.07	58.97
PI positive thinking	76.23	71.29
PI social source monitoring	76.47	71.29
PI monitoring – creating – executing subsystem	74.03	70.38
PI self-efficiency	74.56	70.55
PI creativity	73.27	69.82

PI social source founding skills	70.11	66.92
PI self-regard	77.05	71.70
support seeking coping strategy	70.38	68.03

We gathered our data in a period, where not just ordinary stressors appeared but in 2019 we had to face a pandemic situation. So, the question arises to what extent the pandemic situation may have affected students' psychological health. Is there a factor that became significantly different between faculties only during this period? The important question is mainly, if so, what could be the reason for it?

There are 8 psychological factors that showed no significant difference in 2018 but showed in 2019 and 2020. In Table 4 the averages for the two years where there was difference (marked with S in the headline) (total number of participants = 1889) are listed, and for examining the change in psychological factors we added the averages of the year when there was no difference yet (marked with NS in the headline).

Table 4

Changing tendencies of psychological factors between 2018 and 2020 with a significant difference between faculties in the last two years, scores given in percentages

Psychological factor	Avg. managers 2018 (NS) (n = 177)	Avg. IT-people 2018 (NS) (n = 239)	Avg. managers 2019 (S) (n = 341)	Avg. IT-people 2019 (S) (n = 431)	Avg. managers 2020 (S) (n = 475)	Avg. IT-people 2020 (S) (n = 642)
EQ-I intrapersonal scale	68.12	65.86	54.79	56.52	69.89	71.32
EQ-i stress management scale	63.31	62.79	60.58	59.58	64.30	74.43
EQ-I reality-testing	63.49	63.34	56.63	57.76	65.97	70.31
EQ-I happiness	74.66	72.61	66.55	65.05	80.45	70.05
PERMA engagement	75.81	73.28	75.40	72.63	74.37	71.03
PERMA health	72.62	69.32	70.49	66.20	73.43	70.37
PI social mobilizing skill	75.57	72.71	73.86	70.69	75.66	65.47
acting out coping strategy	56.41	55.79	60.23	57.33	61.44	57.46

As the coronavirus caused serious restrictions in Hungary in the second half of 2019/20, the psychological factors that became significantly different by 2020 may also be of interest. There are 9 such factors, which differed significantly only in 2020. Beside the results of 2020 we also listed the ones from the previous years to take a look at the changes on the factors. In Table 5 are shown the averages for the non-significant and significant years (marked by S and NS) as above.

Table 5

Changing tendencies of psychological factors between 2018 and 2020 with a significant difference between faculties in the last year, scores given in percentages

Psychological factor	Avg. managers 2018 (NS) (n = 177)	Avg. IT-people 2018 (NS) (n = 239)	Avg. managers 2019 (NS) (n = 341)	Avg. IT-people 2019 (NS) (n = 431)	Avg. managers 2020 (S) (n = 475)	Avg. IT-people 2020 (S) (n = 642)
EQ-I self-regard	79.93	77.35	51.68	53.29	79.26	54.68
EQ-I problem-solving	75.30	74.84	66.24	67.45	76.26	64.84
EQ-I adaptability scale	66.93	66.99	59.31	60.30	69.74	72.38
PERMA negativity	57.33	56.89	57.18	55.72	53.16	70.34
PI challenge seeking	72.04	70.17	67.60	66.64	72.58	72.59
PI persistence	72.99	70.81	63.74	62.76	75.36	67.90
PI sense of coherence	74.71	72.63	61.18	60.13	76.23	71.09
self-punishment coping strategy	65.62	65.65	61.57	63.46	58.71	58.50
acquiescence coping strategy	59.25	60.84	60.41	60.13	56.09	62.12

Of the remaining 25 factors, 11 were those that showed a significant difference only in 2018 and 2020, while another 3 only in 2019. 3 psychological factors differed significantly in 2018 but were non-significant in 2019 and 2020.

5 Discussion

Our study aimed to examine the differences and similarities between students of economic major (considered future managers) and students of electrical engineering major (considered future IT people) in some psychological characteristics, mainly from the field of positive psychology. We measured Eysenck's personality dimensions, emotional intelligence competencies and skills, positive source competencies and coping skills, the latter from behavioral, mental and psychological aspect too. In every aspect we found some results worth mentioning, which let us anticipate gaps and bridges between managers and IT people later in workplaces. First, we discuss the personality and competency differences of the two majors' representatives.

The main difference is given by the personality factors. We found significant differences in extroversion over the years. Future managers showed higher rate of extroversion, which means they prefer being among peers, seeking social support and actively forming new relationships. Although Kline and Lapham [17] and Rubinstein [18] could have delivered supporting evidence for distinct personalities of different faculties' members, they could have not shown significant difference in extroversion. We disconfirmed their outcomes and proved that there are differences between engineers and economists in their level of extroversion. These differences are strengthening the evidence of Vedel, Thomsen and Larsen [40] who found that science students have the lowest level of extroversion in comparison to medicine, political science, arts and humanities academic majors. These findings are also consonant with the preconceptions that engineering students are more introverted than other students.

We also found that emotional stability is higher in case of future managers and future IT people scored higher on rigidity scale. Although these outputs were not significant, they show us there should be some differences in how the members of these faculties process and manage their feelings. For this reason, we also compared the emotional characteristics of students.

Using Bar-On's EQ-i questionnaire, the main difference appeared to be on the factors of interpersonal characteristics and general mood. These findings are consonant with the previously described differences in extroversion according to that engineering and economist students differ in their eagerness to socialize. In their emotional competencies this difference means that economist students are socially more aware, open to other people and to the feelings of others and relate well with others. In term of general mood, economist students can motivate themselves better than engineering students. The level of some emotional facets of economist students also diverges form the results of engineering students. Future managers reached higher level on empathy, social responsibility and interpersonal relationship too. This means they understand easily others and their emotions, they also sometimes identify themselves with emotions of others and with social

groups while cooperating or approaching new people. In contrast, engineering students had a higher level on independence facet, which indicates they are self-reliant and do not depend on others emotionally. However, according to the lower means in most of the facets, future IT people still have to work on these competencies to be emotionally more accepting and conscious, not just in their social relations, but in their relation to themselves too.

Even though emotional intelligence seemed to be higher for science students on independence facet and their higher emotional intelligence is supported by some studies [20; 41], we found that future managers assessed higher their emotional intelligence in most of the cases. Kafetsios with his colleagues [20] suggested an answer why emotional intelligence measured by different type of questionnaires can result in contradictory outcomes. They found that science students score higher on trait emotional intelligence measurements, whereas social science students reached higher level of emotional intelligence when it was measured with an ability-based instrument.

Beside emotional aspect, we examined psychological aspects too. Positive source competencies of the PERMA-Profiler gave a holistic picture about the well-being of our participants. Over the years we found in positive emotions and happiness significant differences between the two groups. Economist students already showed a higher general mood in EQ-i and due to this ability, they can report higher level of happiness and positivity too. To the best of our knowledge, no one examined the well-being of university faculties separately and so made no such a distinction between groups of students.

Another type of positive source competencies describes the behavior in stressful situations and shows the preferred coping style and consider our mental and psychological reactions under stress. Therefore, we used Psychological Immune System Inventory [37-38] to understand the stress reactions of students from both faculties. Economist students prefer significantly more the coping assets of the approach-belief and the monitoring-creating-executing subsystem. They try to adjust more to the environment and manage their emotions, behaviors and thoughts than engineering students. Moreover, they look for external and internal sources when coping with stress. As already mentioned, they are optimistic about their life, and our results confirmed that they are characterized by positive thinking, are open to their milieu and ready to monitor available social sources. In addition, they are more self-efficient, search for great ideas and new opportunities to solve challenges and collaborate. Meanwhile, they respect their own thoughts, feelings and emotions. In their behavior we can see that they actively search for support and so they rather use a problem-focused coping style in comparison to future IT people. Supporting our results, Austin, Saklofske and Mastoras [42] found a strong correlation between emotional intelligence components and task-focused coping. So, the higher emotional intelligence level reported by future managers implied also a higher preference for task-focused coping style among students compared to the characteristics of future IT people. The characteristics of

faculties might bring with the differences of their admitted students because of faculties' special culture [16], but these assumptions should not be generalized until further research strengthens the variation of the level of well-being, psychological immune competencies and coping preferences among faculties.

Above all, the pandemic should be mentioned, since it was a huge stressor in the last two years and affected physiological, emotional, psychological and mental health of the population. University students had to face lockdown, switch from personal to digital education, get familiar with more teaching techniques and the distance from their peers from one day to another in March 2019 [43]. The impact of the lockdown with digital and later the hybrid education can be the reason that some differences occurred in our results comparing psychological factors in 2018, 2019 and 2020. Generally speaking, the immediate changes in educational setting and everyday life strongly affected university students as represented in the general lower levels of positive psychological factors in autumn 2019.

The emotional reactions to the uncertainty are reflected in emotional intelligence factors. Change management was challenging for both future managers and future IT people in 2019, but they acclimated to the new situation and used their reality testing to accept the "new normal". After they got through this situation future IT people reached a significantly higher level of adaptability and stress management, according to that they tolerated better the hybrid education and social distance from their peers. Both groups had to adapt to the new circumstances and after a lower level of happiness reported in 2019, they scored higher on this scale, future manager even higher than future IT people. This might be caused by the happiness of reuniting with peers thanks to the hybrid education and lowering restrictions. While IT people relied on themselves utilizing this period for developing higher self-awareness and emotional self-consciousness and this possibility for inward oriented attention probably made them happier.

In positive psychological source competencies, we also found that engagement of our students lowered with the time and they lost on their enthusiasm year by year. Their perception about health also showed a slight decline in 2019, but got back to a higher level by 2020, after recovering from illness or collecting good experiences in their environment. The surprising result was that negativity of IT people has risen this year after a moderate decrease in 2019, while reported happiness also has risen to 2020 in their case. The reason might be that they have learned how to be aware of their emotions and be able to express them, so they reported more intensive emotions in 2020 after thy experienced them in the uncertain period.

What helped students through the digital education and the hybrid period, can be described by taking a look at the psychological immune competencies and coping strategies. Social source founding skills and sense of coherence helped future managers through the tough times, when they were able to use again their social relations to recharge and so find again harmony in their lifestyle and emotions.

Although future IT people also reached a higher score on sense of coherence in 2020, their level of social mobilizing lowered year by year. It makes sense because they were rather monitoring themselves and as more introverted students leaning on their own competencies, staying open to challenges and being persistent. They also used emotion-focused coping strategies, like acquiescence to lower their distress and this helped them lower their tendency to self-punishment. Future managers also preferred emotion-focused coping strategies, such as emotional emptying with a rising tendency for acting out. Thus, their coping strategies directed not toward themselves, but rather aimed to catch the eye of others and so manage stress.

Our results show that this younger, in digital world more experienced generation also suffered from the forced digital education and social distance. Later, there might be also difficulties when future managers and IT people will work together but raising awareness in previously described characteristics might help building bridges between the representatives of the two distinct field and fostering concentration on their similarities when working together in challenging times.

Conclusion

The current trends in human resources management do not question the power and value of employers. The goal of most companies is to select the best fitting members, even managers or employees who are qualified and experienced. To reach a competitive advantage with human resource, the HR elements as organizational culture and high-quality interpersonal relationships should be important part of organizational strategic planning [44].

Based on our results, many significant differences are between management and informatics students, however, they have to work together in their future workplaces. Our study showed a basic difference among personality traits, like extraversion and introversion. In a context of a workplace, personality can't be developed but the recognition of the differences and using the strength of these characteristics is a good way of acceptance. Introverted people like to work alone, independently and can concentrate or focus for a long time. Communication might be a bit difficult between extroverted managers and introverted IT people but if managers notice this evidence and can use more appropriate communication then IT people can work hard on their tasks. To find the best way of cooperation, emotional intelligence can play a key role. Differences in self-knowledge may foster interpersonal conflict or feelings of workplace stress or dissatisfaction from both sides which can lead to fluctuation. To prevent these harmful situations and progresses, development of social and emotional skills are needed. Elements ofsuch a training program could be competencies from EQ-i or PERMA elements, and adaptive coping mechanisms. Building of a positive emotional climate at the workplace affects positively not only on interpersonal satisfaction but on the other hand it has a positive effect on performance and business or organizational success [45]. Human resource staff faces these challenges in form of everyday

small conflicts but with this evidence-based conclusion, they can renew human resource processes like talent management, assessment, development, or feedback systems. As Hitka et al. [46] found the management has to take employers needs into account which can vary across cultures or any other agents. The higher level of emotional competencies of managers are important because they can be aware of motivational needs and can build the unique way to motivate IT people, which is a key of job satisfaction.

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The Impact System of Science Centers and their Activities, in Support of Public Education and Career Guidance, during the COVID Pandemic

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Abstract: This paper investigates the complex impact system of the science centers, that play a key role in STEM career orientation and a draft model, for measuring these impacts. A review of the range of science centers in Hungary and an examination of the location of them provides an overview of this industry. Presentation diverse goals of science centers, their functions, along with the spatial effects of different activities, based on the comparative analysis of two institutions is presented herein. In addition to that, the paper also discusses the rural development impacts of science centers through a promising practice, and investigates innovative ways in which science center's support public education and STEM career guidance during the COVID-19 pandemic. This research is based on the review of the current international literature on science centers. Subsequently, the Hungarian science center ecosystem is described through the analysis of public data, supplemented by the authors' personal, professional experiences in the analysis of the institutions and projects presented using a case study approach. The results show that the importance of science centers goes far beyond their function as tourist attractions, and that regular participation in their programs can enrich the knowledge base of their host city and agglomerations. The study indicates that science centers have all the required tools and methodological experience to effectively support public education in STEM fields. Finally, their ability to adapt quickly to changing circumstances, during the COVID-19 epidemic, demonstrates a "future-oriented" approach and tremendous innovation potential that are inherent in these institutions.

Keywords: science center; public education; educational methodology; STEM; economic development

1 Introduction

Changes in the global labor market and demographic processes have been increasingly challenging since the turn of the millennium. Our transforming world is characterized by the breakthrough of STEM areas, the rapid spread of digitalization and robotics, and the expansion of the knowledge economy [1] [2]. The investigation of science centers is considered to be particularly important as they can be especially effective in the playful presentation of STEM fields that offer secure livelihoods, challenging jobs and diverse tasks. This special kind of institution plays a key role not only in arousing interest in STEM areas, but in a broader sense, also in presentation of science and technology, in developing the general knowledge capital of a region, and in building basic scientific literacy, that is essential for understanding and processing everyday phenomena.

The research is characterized by a duality: On one hand, it aims to provide a general overview of the science center ecosystem in Hungary, and on the other hand, it examines its specificities. The different objectives and operating models of science centers are illustrated by comparing two institutions. Finally, innovative methods to support public education and STEM career guidance during the COVID-19 pandemic are described using the example of a specific institution, Mobilis Science Centre in Győr.

Among the novelties of this paper, two factors should be highlighted. The complex approach to examining the science center industry in Hungary is unprecedented in the domestic professional discourse, and the use of draft model under development makes it possible to examine the complex impact system of the science centers. This can be suitable for the self-evaluation of institutions, but also for comparing the development and progress of science centers with similar goals and backgrounds.

2 Preliminaries

The main goal of today's science centers is to arouse the interest of their visitors in the world of science and technology through the method of experiential learning. Their unique exhibits form a special interactive playground which allows them to teach visitors in a playful way. The widespread methods of experiential learning are frontal science shows and interactive workshops, scientific experiments made by visitors, tinkering activities, robot programming sessions or demonstrations of technologies such as Leonar3Do VR system, VirCa, MaxWhere, Microsoft HoloLens or Oculus Rift, that can determine future of work and education [3-6]. The world of science centers bear many similarities to modern museums and some additional non-formal learning arenas, making it difficult to draw the boundaries of this particular type of institution.

The range of Hungarian literature investigating the operation of science centers is very limited, but the research of traditional North American and Western European institutions has been going on for much longer. Outstanding from the literature is the debate between Bradbourne [7] and Persson [8] around the turn of the millennium about the present and development potential of science centers. While Bradbourne compared science centers to endangered species and urged the creation of a new type of institution, Persson reported about a dynamically evolving industry. He refuted point-by-point criticisms of the operation of science centers, reporting on innovative, constantly evolving, sustainable, multifunctional institutions with much lower support than other learning arenas.

Persson [9] and Garnett [10] examined the impact system of science centers in a complex approach and distinguished four different types of impacts: personal, social, political and economic impact. In his study synthesizing results of about 180 previous researches, Garnett found that the vast majority (87%) of previous studies investigated the personal impacts of science centers. Meanwhile, only 9% focused on social impacts, barely 4% analyzed the economic impacts of the centers, while their political impact was virtually unaddressed in the literature.

Most scientific results proved personal impacts of science centers, mainly by summarizing the effects on visitors' knowledge level, attitudes towards science and openness to STEM careers. In their extensive study, Falk et al. [11] [12] measured the impact of 17 science centers in 13 countries, involving more than 6000 young and adult visitors. Visits of science centers were found to be positively correlated with level of knowledge, understanding of science and technology, positive identification with science, and openness to related leisure activities. Bamberger and Tal [13] measured the effects of using three interactive exhibits of Israel Institute of Technology over two different time periods: one day after the visit and 16 months later. The authors proved that the visit have long-term benefits: one-third of test subjects were able to connect their experiences to their studies months after the visit, and memories caused by science center exhibits did not fade even after 16 months.

The research of Groves [14] focused specifically on the economic impact of science centers. It found it significant, as the 199 institutions surveyed had a total operating cost of more than 1.1 billion USD per year, an annual investment of more than 300 million USD and they recorded nearly 77 million visits in a single year.

Presentation of Persson [15] at the ECSITE 2015 Annual Conference, can be considered as summary of previous research. He summarized previous findings proving that science centers had a positive impact on the level of knowledge, attitudes, academic interest, school performance, and openness to STEM career of their visitors both in the short and long term. He also highlighted the economic impact of the industry, estimating it at 7-17 billion USD, a year. He emphasized that the unit cost per visit was much lower than for other learning arenas. Going

beyond previous research, he illustrated with many examples that science centers could play an important role in supporting cultural tourism and public education, as well as in regional development and urban rehabilitation. Dissatisfied with these results, Persson called for a strategy to position science centers as an essential player in education, science and technology.

3 The Proposed Method/The Thesis

Investigating the impact system of science centers is one of the main topics of our ongoing research. Based on the first results of it and on nearly a decade of work experience in this industry, we intend to go beyond former findings of the literature to the extent that in addition to personal and economic impacts, we also attach great importance to social and environmental factors. Examining the operation of science centers, we see their real impact system in the unity of these four areas (Figure 1).

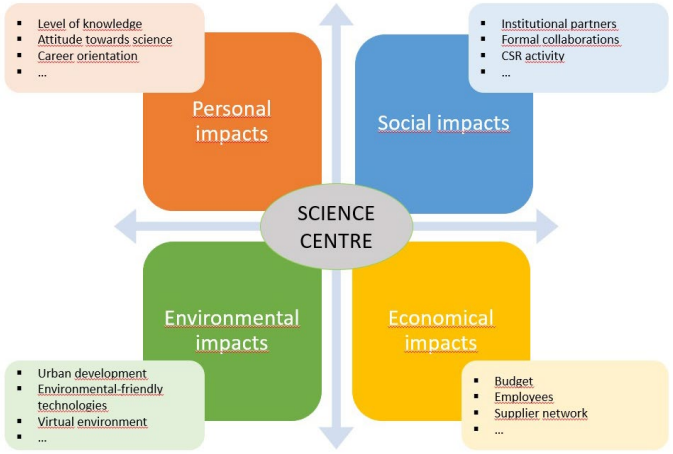

Figure 1
Impact system of science centers

As part of this research, in addition to developing a model for measuring the complex impact system of science centers, we provide a general overview of this industry in Hungary. Where do the boundaries of this particular type of institution lie? Which institutions can be considered as “classical” science centers?

As result of this research, a model is going to be developed, that can be suitable primarily for investigating the impact system of science centers, but can be also appropriate for demonstrating the impact of further non-formal learning arenas, e.g., museums, zoos or agoras. We divide each of the above mentioned four

dimensions into 5-8 subtopics, so the complex impact system of an institution can be investigated along progress in 20-30 different themes.

The characteristic of each subtopic can be associated with multiple possible outcomes, so the progress of a particular subtopic can be determined on a Likert scale. As a result of the analysis this way, the impact system of the examined institutions can be represented graphically in an easily interpretable way. A simplified model of this is illustrated in Figure 2.

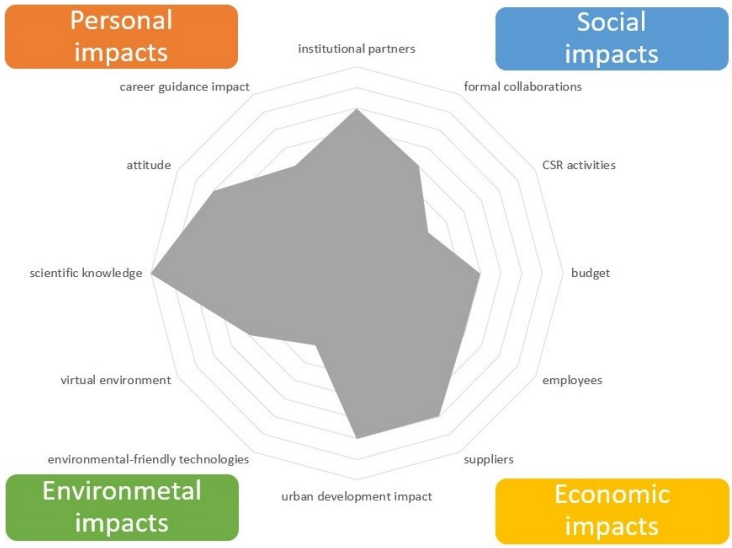

Figure 2
A simplified model to illustrate the impact system of science centers

The model can be excellent to use for self-evaluation of an institution, for illustrating results achieved so far and for identifying development potential. Its main aim is to examine the life-cycle and the development of an institution, e.g., by measurements before and after the implementation of a key project. In addition, it may be even suitable for comparing different institutions operating in a similar socio-economic environment. Along with recording the progress made in 20-30 subtopics, we consider it intriguing to identify and share the promising practices related to them, thus also fostering opportunities for further development.

As part of our research, in addition to developing a model for measuring the complex impact system of science centers, we provide a general overview of this industry in Hungary. Where do the boundaries of this particular type of institution lie? Which institutions can be considered as „classical" science centers and which further centers carry certain characteristics of this type of institution? How are these institutions located in the country? Through personal data collection from

two science centers in Hungary, we illustrate how different goals and philosophies can characterize these institutions. In addition to the four-dimensional impact system outlined above, we examine an additional aspect: When analyzing any kind of impact, the geographical area in which it appears is particularly important. As part of this study, we show how the territorial scope of science centers can be interpreted.

4 Discussion

4.1 Science Centers in Hungary

The first science center of Hungary was the Palace of Miracles in Budapest, the history of which began with a highly successful temporary exhibition in 1995, followed by conceptualization of a permanent exhibition. The location of the institution has changed several times in recent decades. Its 5000 m² scientific playground with more than 250 exhibits has been welcoming its visitors to Óbuda since 2017.

In the 2010s, further science centers were established in three other cities. In March of 2012, Mobilis started its operation on the campus of the Széchenyi István University in Győr. The first thematic science center in Europe focusing on vehicles, mobility and transport is located in an imposing building that resembles the piston of a Wankel engine. Its 1200 m² exhibition space features more than 70, largely unique, interactive exhibits. Thanks to its continuous development, since 2018 Mobilis has included two additional centers: Mobilis Student Laboratory, which supports public education with experiment-based STEM programs and innovative pedagogical methods, and MobilITy-Győr Digital Experience Centre, which covers our entire digital world. Futura Science Centre in Mosonmagyaróvár also opened its doors in 2012. It was established by the rehabilitation of an industrial building that was hundreds of years old at the time. Futura presents natural sciences, including the four elements (water, earth, air, fire), as well as the values of Szigetköz and Danube River to its visitors. The Agóra Science Centre has been operating in the botanical garden of the Great Forest in Debrecen since 2015. In addition to the classical exhibits that can be found in many other centers, the exhibition space also offers unique attractions developed by corporate partners. In the spring of 2020, the DigITér Digital Experience Centre started operating in Agóra, which carries out activities similar to MobilITy in Győr.

Some institutions do not have all the features of classic science centers, but at the same time, they have many similarities with the tools or methodology of them. In Hungary, these include Laboratory – Interactive Magic Square (Pécs), Szent-Györgyi Albert Agóra (Szeged), Magic Tower (Eger), Kemenes Volcano Park

(Celldömölk), Pannon Observatory (Bakonybél) and Zselic Star Park (Zselickisfalud) In figures below, the latter institutions are referred to as "further interactive science demonstration institutions".

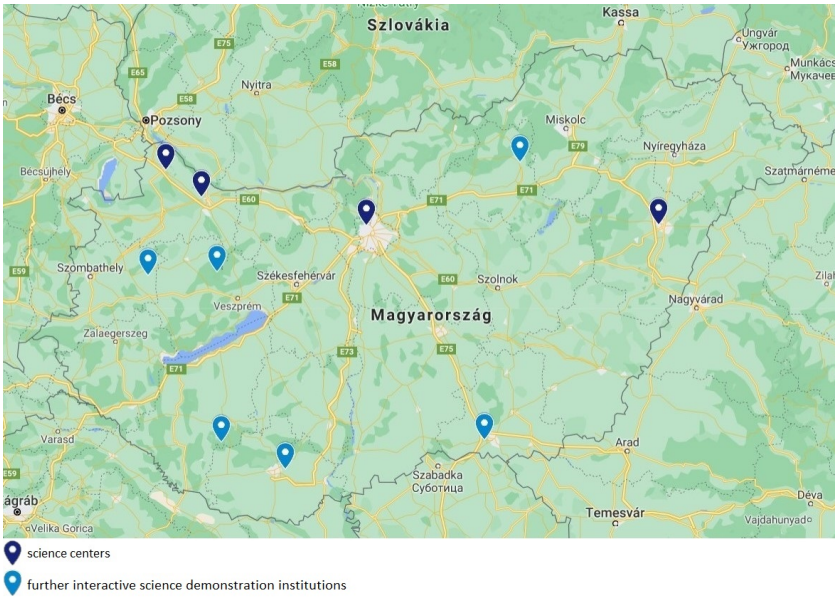

Figure 3
Science centers and further interactive science demonstration institutions in Hungary

Based on Figure 3, it can be stated that a significant part of the Hungarian science centers and further interactive science demonstration institutions are located north of Lake Balaton, so the residents of the already developed Central Transdanubia and Western Transdanubia regions access their services most easily.

After opening of new institutions in the first half of the 2010s, no further classical science centers were established in Hungary. At the same time, non-formal learning arenas offering innovative experiential pedagogical methods have been enriched in several waves in recent years. Following the example of MobilITy in Győr and DigITér in Debrecen, a digital experience center with similar functions, EDU&FUN, has opened its doors in Budapest. The infrastructural and methodological development of science education was aimed at a Human Resources Development Operational Program (HRDOP) tender, which provided an opportunity to establish 13 further science experience centers in 2018-2019. These developments were realized from a much smaller investment than classical science centers. Their methodological significance is much more emphasized than the implemented infrastructural development.

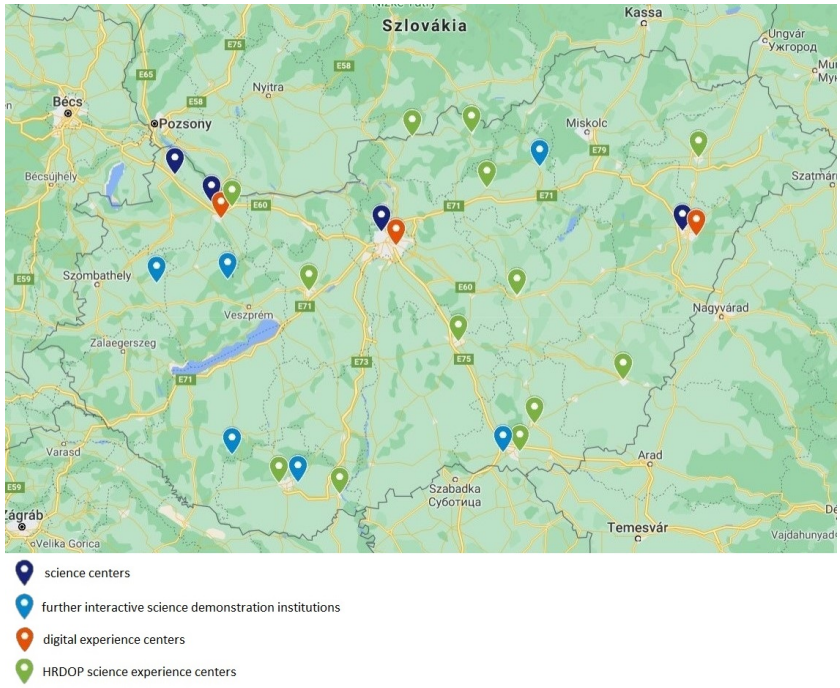

Figure 4
Innovative non-formal science learning arenas in Hungary

If we complete the series of science centers with these institutions, an interesting territorial rearrangement can be observed. There are cities (Budapest, Debrecen, Pécs, Szeged) with two, experiential educational centers, and the city of Győr operates three centers (Mobilis, including Mobilis Diáklabor and MobilITy-Győr Digital Experience Center) within one institution. It is gratifying, that modern experiential pedagogical programs are available for the region of smaller towns, such as Balassagyarmat or Gyöngyös. At the same time, it is unfortunate that big cities like Miskolc still do not offer this useful and innovative form of learning, and large areas in the northeastern and southwestern part of the country are lacking such services.

The representatives of science centers in Hungary can typically look back on a history of only a few years, and a scientific impact assessment of their operation is still pending. Most of them act as a kind of tourist attraction, offering fun and useful leisure opportunities for families or school groups, while others consciously develop their activities towards the function of a career guidance or STEM education methodology center.

4.2 Main Goals and Mission of Science Centers and their Impact on their Region, Following the Example of Two Institutions

The possible functions of science centers and their impact on the urban area are further examined through the example of two institutions in Western Hungary, Futura in Mosonmagyaróvár and Mobilis in Győr.

Mosonmagyaróvár is the 3rd largest city in Győr-Moson-Sopron county, with about 70,000 people living in its agglomeration. It has an excellent transport infrastructure, the proximity of two capitals (34 km from Bratislava and 84 km from Vienna) and the significant gravitational force of Győr (39 km) make it an important economic, transport, industrial and commercial center. The Lajta River and the Mosoni-Danube branch, crossing the settlement, as well as the Szigetköz, hides extraordinary natural values, which are also presented in detail by the science center of the town. The agglomeration of Mosonmagyaróvár extends beyond the borders, and its infrastructure and services (e.g., healthcare and beauty industry) are used extensively by Austrian and Slovak guests. The micro-region hosts companies of the automotive industry with significant economic potential. The agricultural and food science courses of its higher education institution, are nationally recognized, and it has been operating as a faculty of Széchenyi István University in Győr since 2016. According to spatial relationship analysis of Szörényiné Kukorelli [16], Mosonmagyaróvár is a medium-strength area-former center and its gravitational space breaks its independent attraction from the district of Győr. The town is growing dynamically and has significantly increased its weight since the turn of the millennium.

Győr is a settlement with significant industrial tradition and a hub of excellent transport infrastructure. It was the 5th largest rural city in Hungary, with 124685 permanent residents in 2019. In addition, there are thousands of people who are permanently in Győr due to work or study, so its actual population is well over 130,000. Based on its city rank, infrastructure and economic performance, it is an outstanding settlement in CEE. Today, it has become a major economic center of Hungary [17], thanks in large part to Audi Hungaria and its supplier network, which has been operating for more than 25 years in the city. Audi Hungaria operates the largest engine factory of the world in the city, also has a large volume of vehicle production and has recently made major developments in e-mobility. Its economic strength is well demonstrated by the fact that in 2016 it contributed 1.44% to the Hungarian GDP, and it plays a decisive role in Hungary's foreign trade volume, realizing 99.58% of its business turnover abroad. According to 2016 data, it was the 2nd largest manufacturing company in Central Europe in terms of sales revenue [18]. The impact of the operation of the city goes far beyond its administrative boundaries and does not coincide with any statistical territorial unit. Its agglomeration – including service functions, public services, commercial networks and, above all, the labor market – covers an area of appr. 60-80 km and

extends beyond the border of the country [19]. Analyzing the spatial relationships of commuting, Szörényiné Kukorelli [10] states that the pulling effect of Győr is outstanding in all aspects of the study. The city has a significant cross-border labor market attraction that is constantly spreading and expanding. In 2011, more than 30,000 crawlers worked in the city [20]. In recent years, presumably due to the very favorable labor market indicators of the Győr district, the role of more remote settlements in the agglomeration has become more important. Based on the above, it is easy to see that the performance of the economy of the city is closely related to the quality of life and opportunities of the entire urban area.

The range of science centers is examined below. The term range is hereinafter referred to as a specific part of the geographical area where a certain effect applies. In this sense, the range of science centers can be defined in several dimensions. Due to the often-repetitive nature of the activity, some of their services (e.g., outsourced school activities, study groups, etc.) serve the needs of the population of the settlement hosting the institution and the villages in the immediate vicinity of the city. We consider this to be the primary range of a science center. At the same time, users of other services (e.g., the unique interactive playground) can come from a much larger area, even from regions more than an hour's drive away, e.g., as a member of a group on school class trip or on a weekend family trip. The area covered by the latter function is considered to be the secondary range of science centers. Due to the distance between Győr and Mosonmagyaróvár (39 km and approx. 40 minutes), the primary ranges of the centers are spatially separated, but their secondary range with the function of a „tourist attraction" almost completely overlaps (Figure 5). Interestingly, the latter factor does not cause any tension in the operation of the institutions. They regularly participate at public events of each other (e.g., Experiment Bazaar in Mobilis), promoting attractions and services to visitors and strengthening the professional community of science centers.

Futura, like many other science centers, defines itself primarily as a kind of tourist attraction due to the uniqueness of the institution. The main goal declared by the maintainer is that the center should contribute to the increase of the tourist attraction power of the city and Szigetköz. In highlighted positions of its website are published information (e.g., school class trip, information in English, German and Slovak), which indicates that the main target of its services are primarily tourists (families and groups) arriving in Mosonmagyaróvár. Apart from the Birthday Party service, there are no offers or descriptions on the website that would specifically target the population of the town. As a result of browsing the Internet for the science center, its offer and services will appear mainly on thematic websites for tourism or program organization, such as:
www.ittjartam.hu
www.szallas.hu
www.tripadvisor.co.hu
www.gyerekkel.com
www.programturizmus.hu

Figure 5
The primary and secondary ranges of Futura and Mobilis

Since its opening in 2012, the institution has operated as part of the Flesch Károly Nonprofit Ltd, owned by the municipality. In the autumn of 2020, the city council decided to continue its operation as an independent financial body from 2021, as Futura Science Centre and Event House. Following the reconstruction of a former cultural institution unused for a long time, the Coast Event House has been operating by Futura since 2021. The main goals of the transformation are to boost special areas of tourism, such as event management and conference tourism.

The Mobilis Science Centre in Győr has also been operating since 2012. Although the institution has become a tourist attraction of the city, it was clear from its opening that Győr and its agglomeration could benefit primarily from its operation. The venue of Mobilis is also symbolic: the center operates in one of the imposing new buildings on the campus of the Széchenyi István University, the dynamically developing higher education institution of the city. The main mission of Mobilis is to promote STEM careers, that provide a secure livelihood, a modern work environment and a challenging job for future professionals. In the first years, the institution was operated by a non-profit Ltd. owned exclusively by the municipality and since 2016, Mobilis has been operating by the university and the city jointly. As a result, a closer professional relationship has been developed between the center and the university.

The unique permanent exhibition of Mobilis, focusing on the theme of transport and vehicles is undoubtedly a kind of tourist attraction. It is a popular venue for families and school groups, especially those who take part in class trips in the spring and early summer. At the same time, while the center can be a one-time program full of fun and experiences for tourists arriving in Győr, it offers regular

recreation and learning opportunities for families in the urban area. Excellent examples of this are study groups, talent management programs, summer camps or science-birthday parties of Mobilis. By the autumn of 2018, Mobilis implemented two significant developments: Mobilis Student Laboratory and MobilITy-Győr Digital Experience Centre. Since this transformation, the institution has been focusing on hosting school groups on weekdays, while retaining its popular "scientific playground" function. Thanks to these developments, the number of visitors showed a continuously increasing trend from 2017, until the outbreak of the coronavirus pandemic.

The management of Mobilis have recognized that a science center can be considered a special tool for economic development, so the relations with corporate partners and sponsors play a particularly important role in the life of the center. Mobilis is able to work especially effectively with companies that attach great importance to the development of diversified educational projects and STEM career guidance activities in their long-term strategies. The science center offers customized services to its corporate partners, that enable them to achieve their common goals: shaping the attitudes of upcoming generations and promoting STEM careers.

4.3 Science Centers, as Innovative Tools of Rural Development

In 2017, the Government of Hungary called for tenders for the development of experiential pedagogical programs and the establishment of new science experience centers. The aim of the Human Resources Development Operational Program-3.3.6-17 project was to implement experiential pedagogical programs that contribute to the promotion of science subjects, the dissemination of modern, experiment-oriented methodology and, in the longer term, to ensure the supply of professionals and university students in STEM fields. Such institutions have been established in 13 cities across the country, including the Mobilis Student Lab, which has been operating under the umbrella of Mobilis Science Centre, since September 2018.

A new auditorium for 120 people, evoking the atmosphere of university lecture halls has been set up in the Student Lab, as well as professional sound, lighting and projection technology. Well-equipped laboratory stations have also been established, on which, approx. 90 students can perform experiments and measurements, at the same time. Even more important than the advancement of infrastructure is the methodological and curriculum development that Mobilis carried out jointly with its partner schools. As a result of the ongoing consultation that had been taking place for almost a year, 8 different types of activity were designed. All of these aim to support STEM education in schools and to develop methodological skills of teachers. The development of the methodology of STEM education is extremely important, as research examining the effectiveness of

technical training has proven that teaching-learning environment, the instructor's inspirational abilities, and the learning methods have a significant impact on student dropout [21]. Based on results of major international educational surveys [22] [23] and the recommendations of the literature [24], the educational program of the Student Lab was compiled with active participation of teachers from more than 20 schools. The services of Student Lab are free for partner schools, including the transportation if necessary.

The Student Lab is one of the most significant enterprises in the history of Mobilis, and its implementation has brought a complete transformation of the operating model of the institution. Instead of the previous, typically random and, in most cases, one-time visits, classes from partner schools take part in regular sessions integrated into school curriculum, which was a big step forward in increasing the number of visitors: 6-7 classes take part in different programs on an average day.

The rural development impact of the project is at least as important: according to the tender, the services of the new science experience center must be provided for at least 10 schools outside Győr, during the three-year project. This means that schools have the opportunity to participate regularly in experimental pedagogical programs, that were previously not users of Mobilis, due to the geographical distance of their settlement, the required time of transport, or financial reasons. Until 2018, rural school groups typically got to the center only once, usually on a class trip and members of returning groups were almost exclusively students from schools in Győr, typically near to Mobilis. Now, classes of rural schools can take part in regular sessions integrated into school curriculum as part of the Student Lab project. Settlements have also been included in the programs of Mobilis, that typically cannot offer experimental pedagogical sessions for their students, due to the differences in the laboratory infrastructure and the methodological skills of teachers. During the first five semesters (September 2018 – January 2021), schools of 17 rural settlements participated in the sessions of Student Lab. The project provides a free shuttle bus service to Mobilis. The number of trips is well illustrated by the fact that the shuttle buses covered 38527 km during the first school year.

Figure 6 shows the location of the rural schools participating in the project. Their average distance from Győr by road is 15-16 km, the most distant settlements are Tét (24 km), Győrasszonyfa (29 km) and Tápszentmiklós (30 km away). Most of the partner schools are located along the traffic route 1401 to Szigetköz and along the major traffic routes 81, 82, 83 and 85. It is gratifying that in addition to developed settlements around Győr (e.g., Győrújbarát, Nyúl) and in Szigetköz (e.g., Győrzámoly, Dunaszeg, Győrladamér), it was possible to involve schools of more disadvantaged settlements in the southern areas of the agglomeration, such as Győrszemere or Győrasszonyfa. At the same time, there is a striking lack of settlements from the northeastern – eastern areas of the city, e.g., Nagybajcs, Vének, Gönyű, Nagyszentjános, Bőny or Rétalap.

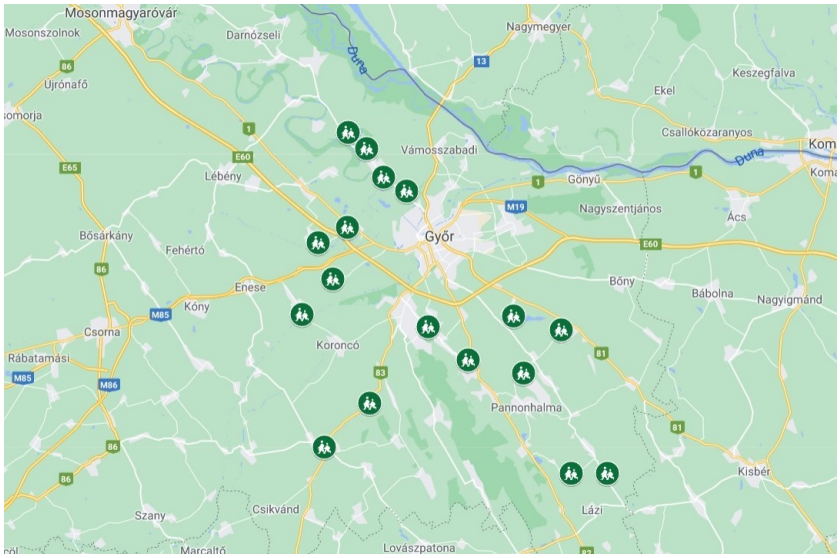

Figure 6
Location of rural settlements participating at Mobilis Student Laboratory project

As partner schools could choose between eight types of sessions based on their needs, and participation at different sessions required different number of visits, there might be significant differences in the total number of Student Lab visits per school.

Table 1
The settlements of schools made most visits to the Mobilis Student Lab per semester

Settlement	Number of visits per semester
Nyúl	650
Győrújbarát	535
Győrzámoly	508
Győrladamér	507
Töltéstava	456

Table 1 shows rural schools that made the most visits to the Student Lab every semester. In addition to pedagogical reasons and the number of students in each school, logistical considerations (amount of time spent on transport) may also have played a role in the background of school managers' decisions on student participation, as it is clear to see that the vast majority of these settlements lie near to Győr.

It is even more instructive to examine how the number of visits made by students of a rural school in a semester compares to the total population of their settlement, as this indicator shows the importance and weight of regular visits to the science center in the life of the settlement.

Table 2
The weight of regular visits to Mobilis Student Lab in the life of settlements

Settlement	Number of visits per semester	Population (persons)	Proportion of visits to Mobilis Student Lab per semester compared to population
Győrasszonyfa	164	530	30.9%
Győrladamér	507	1826	27.8%
Dunaszeg	423	2204	19.2%
Töltéstava	456	2464	18.5%
Győrzámoly	508	3154	16.1%

Analyzing data in Table 2, it can be stated that in relation to the population of the settlements, the students of Győrasszonyfa and Győrladamér are most active, making a number of visits to the science center corresponding to one third to one quarter of the total population of their village every semester. The average distance of the top 5 elements of this list from Győr is the same (15 km) as the total average of 17 rural schools participating in the project. This suggests that in their case, pedagogical considerations, rather than transport or logistics, may underlie the choice of programs that results in more frequent visits. The activity of Győrasszonyfa is especially welcome, as regular participation in experiential pedagogical programs can provide an opportunity to break out for students of settlements located in a less-developed micro-region.

According to feedback of school managers, teachers and parents, Mobilis Student Laboratory program, launched on the basis of results and recommendations of major international educational surveys and specific expectations and needs of partner schools, is of particular value, especially for rural schools. The application of state-of-the-art teaching methods, the implementation of experiential pedagogical programs together with teachers and thus raising the quality of STEM education in partner schools can contribute to the retention of pupils in rural schools, the survival of schools in rural areas, the broadening of services of villages in a broader sense, and the increase in the competitiveness of rural areas.

4.4 Operation of Science Centers during COVID-19 Pandemic

The changes after the spring of 2020, the pandemic that threatened the health of millions, our changed lifestyle and working methods, the economic downturn, the acceleration of technological development, the growing importance of knowledge and adaptability strengthened the role and importance of science centers. Over the past few years, many economies of the developed world have found themselves in a critical situation, and our centuries-old habits have transformed in just a few weeks. In the current situation, one of the main goals of science centers has become especially critical. This is the support of public education, which is closely related to several dimensions of the impact system outlined above

(personal, social, economic impact). In our study, we present how science centers could support public education during the time of homeschooling, through the example of Mobilis Science Centre.

During the lockdown, science centers obviously could not receive visitors and their education projects with the participation of schools were also suspended, or they could be implemented only by using a different methodology than planned before. During the rapid transition to homeschooling, there was a great demand from public education to new types of content and methodological support for teachers. This need was recognized by Mobilis, which responded immediately to the lockdown and started to provide online contents for schools from March 2020.

MobilITy-Győr Digital Experience Centre, operating under the umbrella of Mobilis is presenting digitization and robotics in a playful way. It supported the work of teachers during the lockdown with pedagogical articles and infographics. Tutorial videos were shot for students, presenting e.g., online Artec and LEGO WeDo courses. MobilITy connected to the national Digital Theme Week event with online solutions, programming courses and IT-related tasks. More than 8,000 people participated at the most successful digital detective game developed by MobilITy for the national Sustainability Theme Week. In addition to the successful implementation of nationwide online programs, special attention was paid to local affairs. Accordingly, MobilITy also contributed to the development of a complex student competition of its host city Győr, which was celebrating its 750th anniversary in 2021. During the months of lockdown, along with providing online content, MobilITy also placed great emphasis on self-education, the staff participated at online trainings (e.g., Python and Live Microbit).

In addition to teacher and student experimentation, the use of ICT and the development of multimedia contents play a central role in the educational program of the Student Laboratory presented in detail in the previous section. Within a few days after the official announcement of homeschooling, the shooting of Mobilis School TV recordings began in the empty Student Lab. More than 350 videos were shot and uploaded to the YouTube channel of Mobilis. The videos were divided into 14 different playlists, by grades and subjects. They had a total reach of more than 100,000 views in the first year, and since the return to offline education, they still have 5000 – 6000 views per month. It means that the online contents have become part of everyday activities of public education. After the second lockdown in the autumn 2020, Student Lab organized a large-scale online STEM competition with nearly 5000 participants. Homeschooling was particularly difficult for high school students preparing for graduation, they were supported by online study groups in Physics and Chemistry.

Mobilis has been one of the key players in the STEM career orientation of the Győr Economic District for many years. Its innovative programs present science, technology and related STEM career opportunities for primary and secondary school students facing university. During the months of the pandemic, of course,

career guidance programs could not be implemented with a personal presence either. Among online events, TechTogether Junior Győr online competition was an outstanding one, presenting the diverse training portfolio of Széchenyi István University through experiential and practical tasks. Another exceptional initiative was the online career guidance roadshow, promoting dual vocational training, jointly with Audi Hungaria, the number one employer in the region. This program presented basic scientific phenomena behind technology used by the company for 700 students from 25 different schools.

Another great success of online operation was the LEGO Mentor Program. Training for the global FIRST LEGO League competition is a key project of Mobilis, as it is far more than just a robotics competition. It became a complex career guidance program for kids at age 9-16. Mobilis plays a complex role in the Hungarian FLL community: it organizes regional competitions, provides mentoring for 8 regional schools and in addition to that, it operates an own team. The season 2020/21 was conducted entirely online and the online operation model of Mobilis Bits MRGT team was extremely successful. The team achieved the best result in its history, by qualifying for the World Final in the summer of 2021.

Conclusions

This paper proves that the significance of an innovative science center goes far beyond the function of an "Interactive Playground", with a specific set of exhibits, which guarantees a pleasant and useful pastime. It can function as a methodological center that support schools with variable laboratory background, as well as schools struggling with a shortage of STEM teachers. It is no exaggeration to claim that it's experiential educational programs can also ensure the future of STEM education in Hungary.

Diverse activities of science centers are well illustrated by the example of Mobilis. The paper indicates that a flexible and fast-adapting actor, responding immediately and effectively to the changing needs of public education can support students and educational actors with unique, gap-filling services. It is clear that the host city and its narrow area can primarily benefit from educational programs of science centers. At the same time, the analysis of activities carried out during the COVID-19 pandemic reveals that innovative solutions applied during lockdown may even offer a new perspective for institutions. Application of methods based on direct, personal experience is obviously impossible to replace through online channels, but feedback of school managers and teachers confirm that online contents and methodological support offered great help for educators and students in the period of lockdown. Digital solutions used during the pandemic provide an opportunity for science centers to break out of their traditionally defined range and, albeit in a limited way, to make different impacts, even in a much wider geographical area.

Referring back to the debate between Bradbourne and Persson, institutions with such a profile can hardly be characterized as an endangered species.

The main direction of further research is the refinement of the briefly presented model, with the involvement of recognized experts, in the four fields. After finalization of the model, it can be followed by the evaluation of various Hungarian institutions, which could provide an excellent basis for the management of science centers, for the conscious development of the institutions. Subsequently, in a second phase of research, it is planned to define globally, uniformly interpretable criteria, for each of the subtopics of the model, which will "Internationalize" the tool.

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Labor Market Analysis for IT Jobs

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Abstract: COVID-19 had a serious, negative impact on the economy, as a whole, and on the labor market. The situation has improved recently, but it is useful to map the changes in the labor market and current future trends. Many have lost their jobs, due to the crisis caused by the virus situation and many of them have not been able to get full-time jobs, for extended periods of time. In the technology industry, recruitment is increasing. These global labor market findings raise the question of the characteristics of the Eastern European IT labor market. In this article, the job opportunities are compared, in order to determine in which IT areas, the most job opportunities appear and how they relate to different fields of IT, as services, software development, telecommunication, appliances, electronics, human resources or vehicle manufacturing.

Keywords: labor market; IT; engineering; analysis; Romania; Hungary

1 Introduction

COVID-19 has a serious negative impact on the economy as a whole and on the labor market. The situation has improved recently, but it is useful to map the changes in the labor market and current future trends. Many have lost their jobs due to the crisis caused by the virus situation and many of them have not been able to get full-time jobs for extended periods of time. As a result, there is a risk of long-

term unemployment. In many countries, job retention measures have been the main means of mitigating the effects of the crisis on the labor market. Job retention programs have helped curb rising unemployment.

There have been a number of studies of the global labor market situation. One important finding is that today, 79% of job seekers use social media in their job search and this is even higher, among younger job seekers, at 86% [1]. 40 million people search for jobs on LinkedIn every week, 67% of job seekers use Facebook, 73% of young job seekers found their job through a social media platform [1]. 21% of recruiters admit to having already rejected an applicant after searching on Facebook [1]. According to previous studies, 35% of the announced jobs require at least a BSc, 30% have at least an Associate Degree, and 36% do not require education beyond High School [2].

In the technology industry, recruitment is increasing before or during the pandemic at a level beyond that [3]. The most IT jobs in 2022: database administrator and architect, information security analyst, software developer, network and computer systems administrator, computer programmer, web developer, computer and information systems manager, systems analyst, help desk and desktop support professional, network/cloud architect [3]. On the other hand, IT recruiters and executives say cloud, security, data and artificial intelligence skills are among the coolest jobs in 2021 [4].

The article [4], summarizes the most in-demand jobs in 2021: artificial intelligence (AI) specialists, strategy-minded software developers and managers, business-focused data scientists, data engineers, AIOps analysts, engineers, and architects, cybersecurity architects and engineers, cloud architects, IT directors who demonstrate soft skills. These jobs are focusing on special areas of IT. The highest-paying IT jobs in 2022 among others: big data engineer, information systems security manager, data architect, network/cloud architect [5]. From the above, it can be seen that a wide variety of current IT jobs are typical for 2022, both in terms of job search and salary.

These global labor market findings raise the question of the characteristics of the Eastern European IT labor market. In this article, the job opportunities of the authors' countries, Romania and Hungary, are compared in order to determine in which IT areas the most job opportunities appear, and how they relate to the two countries. The analysis was performed using queries based on the job search page of the LinkedIn portal.

1.1 Situation in Hungary

Despite the adverse effects of the pandemic on most areas of the economy, the IT market has been characterized by new investment and rising wages. According to forecasts, the Hungarian IT market is expected to grow, and companies are undergoing digital transformations in several areas. Following COVID, home work was introduced in many places.

In recent years, the role of customer-centric web development has further intensified, with more and more companies recognizing and focusing on UX / UI Designer activities, as the user interface has a strong impact on website traffic. The importance of the IT Security area has increased, so growth is expected in the coming years, and the DevOps area is characterized by a continuous shortage of manpower [6]. Demand for data professionals has continued to grow, but is increasingly gaining a role in Machine Learning and Deep Learning jobs [6].

IT professionals (41%), manufacturing employees (29%) and manual workers (35%) are most affected by recruitment [7]. Company executives said the epidemic did not have a significant impact on their wage payments projected for 2021. 83% of companies use the home office option [7]. The [7] looked at the extent to which working from home could really become the new norm in the post-virus period. 37% of respondents would allow work from home for 1-2 days a week and 22% for 3-4 days at home, but only 5% would be able to switch to full-time work and just over a tenth of companies would return to office or workplace.

With regard to engineering jobs, there were already difficulties in Hungary last year, which was mostly caused by the downturn in the automotive industry [6]. 2020 has not brought about a significant change in wages or skills demand in the manufacturing sector [6]. On the employee side, stability is the main motivation, while for employers, reliability, flexibility and expertise are paramount [6]. In the field of industrial automation, they are constantly striving to improve their manufacturing technology and increasingly to move towards industrial IT and highly automated systems.

Overall, the past labor shortage has only persisted in some parts of the country due to declining demand, with well-educated, highly skilled job seekers providing a number of good job opportunities. Demand for quality assurance professionals has declined, which can be explained by the postponement of new investments and the wait of manufacturing companies [6]. The demand for development engineers is mostly for those with at least 3-4 years of experience who can use multiple CAD programs at a professional level or speak English at a strong intermediate level [6].

1.2 Situation in Romania

In Romania, according to data provided by the National Institute of Statistics, 19.3 million inhabitants were registered at the beginning of January 2021. According to the Labor Register, of this number at national level, 44% represent the active civilian population, and 64.5% of the active population were employed. The majority of employees, namely 63.3% worked in the services sector, 34.3% of people were employed in industry and construction, while 4% were employed in the IT&C sector [13]. The number of employees in forestry, agriculture and fishing was 2.3%. In 2021, the employment rate of the active population was 71.8% for men and 67.2% for women, so on average 69.6% [13].

On the recommendation of the World Bank's country director for Romania, Elisabetta Capannelli, who said in 2014 that Romania must invest in education, given that, although there are some areas of excellence, 15-20% of the population is below the level of elementary education, investments in the education system have increased [8].

The COVID-19 pandemic crisis severely affected Romania's economic activities, such as hotels and restaurants, population services (e.g., transport, cultural activities). The measures taken to support the companies and employees affected (in particular the measures on leave) had a mitigating effect on the negative impact of the crisis. The average number of employees thus reached 4.9 million people in the period January-November 2020, decreasing by only 1.0% compared to the similar period of the previous year [13].

In September 2020, more than 146,000 people applied for a job, of which 30,000 were new candidates who either did not have an eJobs account or had not been active in recent years. In fact, this was the monthly average of the last period - between 25,000 and 30,000 new candidates applying for the first time or for the first time in a long time in which they have not made a professional change. Many of them are very young, i.e., between 18 and 24 years old, and for them the good news is that start-ups and SMEs, some of the favorite employers for this age group, have resumed significant employment.

In 2021, construction has continued to develop favorably in recent years, but at a slower pace. The tertiary sector will also support this growth, especially through the development of modern services (IT, business services). As for the industry, it has partially recovered, being forecast to reach the level of 2019 by the end of 2022. For the agricultural sector, an increase in production of about 15% in 2022 has been forecast.

Romania is divided into eight administrative regions: North-West, Center, North-East, South-East, South-Muntenia, Bucharest-Ilfov, South-West Oltenia and West [14]. Each region has certain specific features in terms of its economic structure, which is why certain sectors play a predominant role in the development of each region.

At the end of March 2021, the highest rates of registered unemployment were in the South-West region (5.3%) and the North-East region (4.9%). The lowest registered unemployment rates were registered in Bucharest (0.9%) and the West region (2.3%) [13].

The COVID-19 crisis did not bypass the IT field either, with a clear impact in terms of the number of customers, contracts, reorganization of the activity, etc. but the sector was less affected than other sectors whose activity was directly affected by the lockdown period or the maintenance of rules of social distance. IT is a versatile industry, which is familiar with and uses up-to-date digital tools, accustomed to a flexible employee schedule involving remote work, so from this perspective at least formally it has not been affected by the changes that have taken place.

Since the beginning of the pandemic, a series of measures have been established in many IT companies in Romania, mainly in Cluj-Napoca, Bucharest, Iasi and Brasov: from technical unemployment and dismissals, to postponing salary increases, reducing meal vouchers and reducing the work schedule [9].

At several companies, there were teams that completely dislocated and, temporarily, went into technical unemployment during the state of emergency. Other companies have faced freezing, but also project delays, but so far the management has not resorted to staff reductions.

The COVID-19 pandemic has changed the way we work, making remote work a more popular option among employees around the world. In addition, the combination of work and travel is now a growing trend, with many looking for jobs away from home. And Romania, with its fast internet and low prices, can be an excellent choice. A study by Momondo [10], focuses on the reasons that make Romania a top destination for distance work and travel.

Romania ranks third due to low living costs, good prices for car and hotel rentals, as well as low costs for long-term apartment rentals. The excellent speed of the internet and the English-speaking population were also considered advantages.

The ranking [10] analyzed 111 countries, classified according to 22 factors divided into six categories: accessibility and travel costs; local prices; security and health; remote work facilities; social life; and the weather. The state continues to help companies in the IT area with that 10% tax exemption, in addition it has come up with a program for the digital transformation of SMEs, not those in the area of information technology, but also included in the National Investments Plan [9].

2 Materials and Methods

As a first phase, the economic situation of Romania and Hungary will be raised from 2000 onwards in terms of GDP and unemployment. The required data were queried from The World Bank and Eurostat databases.

As a second phase, to compare open jobs, the number of job positions, available from multiple job search portals, was compared to select which job search portal data to analyze in detail. For data analysis, it is advisable to choose a portal that contains as many job announcements as possible for both Romania and Hungary. On the other hand, a query related to the analysis of job announcements can be implemented uniformly for the two countries without distorting the data queried. The following popular job search portals have been selected for preliminary comparison:

- bestjobs.eu
- ejobs.ro
- bestjobs.ro

- profession.hu
- jobinfo.hu
- LinkedIn.com

The portal with the most searchable job announcements, providing a uniform search option for Romania and Hungary, was selected for further analysis of the data.

Due to COVID-19, more and more companies are providing opportunities for remote jobs, which is also the subject of the analysis. Therefore, a job search portal has been selected, the search engine of which also provides an opportunity to search for remote jobs.

As a third phase, the number of job announcements in the selected job search portal was compared across several disciplines, but primarily for IT and Engineering jobs. The number of full-time and part-time jobs was collected during the search for which the portal provided a unified search facility for unbiased data comparison.

3 Results and Discussion

In the following, the results of the 3 phases of the research and the related conclusions are summarized.

In the first phase, the economic situations of Romania and Hungary from 2000 onwards were compared in terms of GDP and unemployment. The results are shown in Figures 1-3.

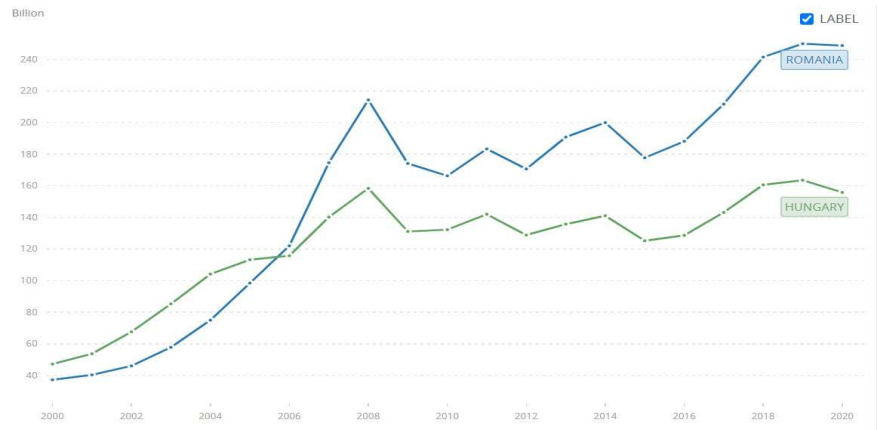

Figure 1
GDP in USD: Romania and Hungary [11]

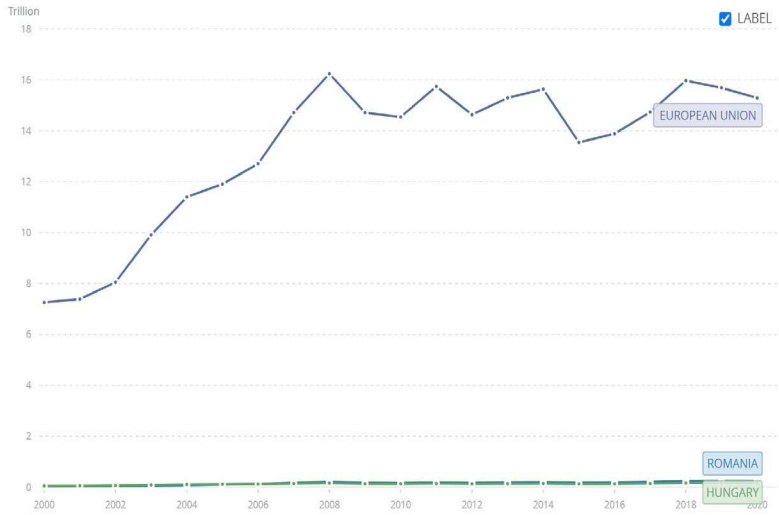

Figure 2
GDP in USD: EU [12]

The graphs show the extent to which GDP fell across Europe as a result of the post-2008 economic crisis, including, of course, Romania and Hungary. Compared to the low point in 2015, a steady increase can be observed in Romania and Hungary in 2016-2018, but in the case of the EU, GDP in 2019 is already declining. The consequences of the coronavirus epidemic were visibly negative for GDP in 2020, with declining GDP in both the EU and Romania and Hungary.

A comparison of GDP between Romania and Hungary since the 2000s shows that Romania has grown at a much higher rate, almost twice as much as in Hungary, but more than three times as much as the EU. However, Hungary's GDP growth also exceeded that of the EU. Romania was able to significantly exceed the outstanding GDP value of 2008 in the years 2018-2020, Hungary only slightly exceeded it in the years 2018 and 2019, and it was not possible to exceed the 2008 GDP value in the EU. Overall, higher GDP growth compared to the EU in Romania and Hungary also had a positive effect on the labor market, mainly in the manufacturing sector, including IT and engineering.

Figure 3 shows the unemployment rate measures the number of people actively looking for a job as a percentage of the labor force from 2016. As it can be seen in the graph, the GDP growth after 2015 also had a positive effect on the unemployment rate. Compared to the EU, Hungary and Romania also have lower unemployment rates, which is presumably due to more favorable GDP growth. Figure 3 shows the evolution of the unemployment rate for the EU, Romania and Hungary since the beginning of 2016. Unemployment is falling both in the EU and in Romania and Hungary. However, the negative effects of COVID-19 are well reflected in 2020 I and II, the rise in the unemployment rate in the third quarter.

However, it is encouraging that from 2021 onwards, unemployment has started to fall again, meaning that there is currently a growing demand for labor in the labor market.

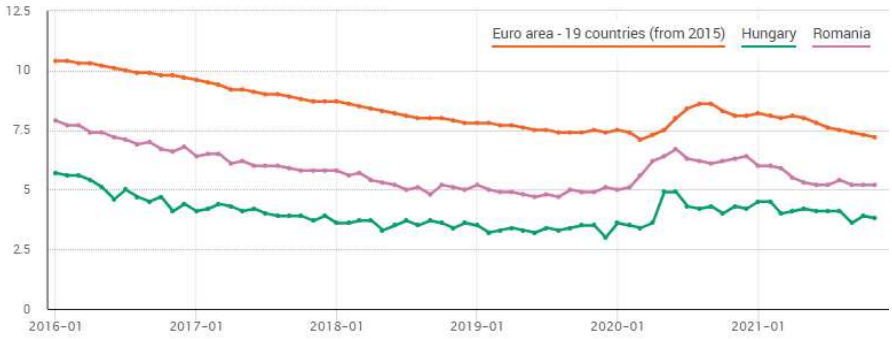

Figure 3

Unemployment rate (%): Romania, Hungary and EU (Source of data: Eurostat)

Overall, the current and expected future situation will have a positive impact on labor market developments. Based on this, it is worth examining which job opportunities are available, taking into account the number of open jobs.

In the second phase of the research, the number of job opportunities offered by popular job posting portals, was reviewed. The results are summarized in Table 1.

Table 1

Total jobs in Romania/Hungary

Portals / Jobs	bestjobs.eu	ejobs.ro	bestjobs.ro	profession.hu	jobinfo.hu	LinkedIn.com
IT / Telecom	304	3919	975	900	2084	11687
IT / Software	119	2130	459	1234	1119	14629
Engineer	57	2265	820	1762	2385	8572
Skilled worker	21	2379	891	6118	6324	1496
HR	42	776	312	691	668	970
Admin. and Secretarial	22	5257	297	1489	2642	1771

Based on the data, it is clear that the LinkedIn portal is the most popular in terms of the number of open job announcements. LinkedIn is one of the largest professional networks on the Internet. LinkedIn can be used to find the right job or internship, search and strengthen professional relationships, and to learn the skills needed to succeed in a professional career. A complete LinkedIn Profile helps to find opportunities by presenting your unique professional story through experience, skills and education.

In order to draw further correct conclusions regarding open job announcements, it is worth comparing that the use of the LinkedIn portal is equally popular in Romania and Hungary. The data in Table 2 can provide an answer to this.

Table 2
Total jobs in Romania and Hungary

LinkedIn jobs	Romani apiece	Romania piece/population	Hungary piece	Hungary piece/population
IT Services and IT Consulting	14516	0.76	6433	0.67
Software Development	10992	0.58	3655	0.38
Telecommunications	1466	0.08	801	0.08
Appliances, Electrical, and Electronics Manufacturing	1372	0.07	1829	0.19
Motor Vehicle Manufacturing	2562	0.13	1535	0.16
Human resources services	1796	0.09	1177	0.12
Internet Publishing	3106	0.16	848	0.09
Financial Services	4854	0.26	2768	0.29
Marketing services	951	0.05	522	0.05
Total	**28 046**	**1.47‰**	**15 451**	**1.6‰**

Romania population: 19034669, Hungary population: 9621547, population rate=1.98

As can be seen in Table 2, the total number of open job announcements and relation to the population also were compared for different fields. Some jobs appear in more than one category, so the sum of the numbers in each field is more than the total number of open jobs. In terms of the number of total open jobs, the use of the LinkedIn portal is similarly popular in Romania and Hungary. In Romania, the number of open job announcements is 1.47 per thousand, while in Hungary it is only slightly higher, 1.6 per thousand compared to the population, that is, the LinkedIn open job announcement portal is only 9% more popular in Hungary than in Romania so it can be used as a basis for comparison.

3.1 Jobs based on LinkedIn

In the third phase of the research the number of open jobs are analyzed, based on the database of the LinkedIn portal. So, the following is a comparison of the number of open job positions on the LinkedIn portal for Romania and Hungary. Considering the population ratio 1.98, the population of Romania is almost twice that of Hungary. The number of job announcements in Romania should be determined by normalizing to the Hungarian population (divided by 1.98), so the number of open job announcements is comparable for the two countries. The results for specified sectors can be seen in Table 3 for full-time jobs and Table 4, for part-time jobs.

Table 3
Full-time jobs in Romania and Hungary

	Romania (normalized)			Hungary		
Jobs	**On-site**	**Remote**	**Hybrid**	**On-site**	**Remote**	**Hybrid**
IT Services and IT Consulting	4310	1203	473	4107	520	436
Software Development	3620	646	234	2101	408	185
Telecommunications	528	46	34	525	74	26
Appliances, Electrical, and Electronics Manufacturing	518	22	20	1493	52	30
Motor Vehicle Manufacturing	675	61	111	1103	36	125
Human resources	621	38	32	735	24	35
Internet Publishing	764	430	53	345	251	34
Financial Services	1624	131	143	1883	58	125
Marketing	257	45	32	329	25	28
Total	**6332**	**1635**	**824**	**6658**	**933**	**820**

Romania (normalized): numbers divided by population rate 1.98 and rounded

Table 4
Part-time jobs in Romania and Hungary

	Romania (normalized)			Hungary		
Jobs	**On-site**	**Remote**	**Hybrid**	**On-site**	**Remote**	**Hybrid**
IT Services and IT Consulting	28	12	0	66	45	2
Software Development	24	1	0	24	1	1
Telecommunications	1	0	0	28	1	0
Appliances, Electrical and Electronics Mfg.	9	0	0	17	0	0
Motor Vehicle Mfg.	16	0	0	25	0	0
Human resources	5	1	0	1	1	0

Internet Publishing	1	10	0	5	3	1
Financial Services	15	1	1	7	0	2
Marketing	3	2	0	3	3	0
Total	**100**	**26**	**1**	**176**	**54**	**6**

Romania (normalized): numbers divided by population rate 1.98 and rounded

The total number of full-time job opportunities is 4.5% higher in Romania and the remote full-time jobs are 75% higher. Some jobs may appear in more than one category, so the sum of the numbers in each field is more than the total number of open jobs.

The total numbers of IT Services and IT Consulting full-time jobs are 18% more in Romania but the remote jobs are 131%, hybrid 8% more. There are much more, 67% more Software Development jobs in Romania. Software Development jobs are 72% more for one-site, 58% more for remote and 26% more for hybrid than Hungary. This means that the number of job announcements in the IT field is relatively higher than the number of job announcements in Hungary. IT Services and IT Consulting full-time remote and hybrid jobs are 28% in Romania and 23% in Hungary relative to total. But these values for total Software Development jobs are 19% for Romania and 28% for Hungary. Employers in Romania and Hungary are also open to remote work in the IT sector.

There are slightly more job opportunities in Hungary, in the Telecommunications sector, in this case there are more opportunities for remote work in Hungary.

There are much more job opportunities in Hungary in the Appliances, Electrical, and Electronics Manufacturing sector. The total number of jobs is 181% more in Hungary than Romania, remote and hybrid work are similar.

The open positions in Motor Vehicle Manufacturing is more in Hungary, than in Romania, with 49%, but there are more remote work opportunities in Romania, while the hybrid is a little bit higher in Hungary.

The number of part-time job open positions is negligible compared to full-time job opportunities. The part-time jobs are 74% higher in Hungary. Hungary has much more Telecommunications and IT Services and IT Consulting open part-time jobs.

3.2 IT Software Jobs based on LinkedIn

The open IT software jobs are summarized in Table 5 for full-time jobs and Table 6 for part-time jobs.

The total number of full-time IT job opportunities is 59% higher in Romania and the remote full-time jobs are 98% higher. Some jobs may appear in more than one category, so the sum of the numbers in each field is more than the total number of open jobs. It can be seen from the table that in all respects there are significantly more open IT software jobs in Romania than in Hungary. From this it can be

concluded that Romanian companies want to develop very much in the field of software, and they may have significant market opportunities in this field.

Table 5
Full-time IT software jobs in Romania and Hungary

	Romania (normalized)			Hungary		
IT jobs	**On-site**	**Remote**	**Hybrid**	**On-site**	**Remote**	**Hybrid**
Software Engineer	3621	646	234	2101	408	185
Senior Software Engineer	317	200	52	263	88	48
Java Software Engineer	242	143	55	175	51	51
Javascript Developer	246	175	52	174	65	64
Back End Developer	312	226	71	223	82	66
DevOps Engineer	231	138	51	169	59	33
Full Stack Engineer	582	317	112	451	180	119
Total	**5552**	**1847**	**628**	**3556**	**933**	**566**

Romania (normalized): numbers divided by population rate 1.98 and rounded

Table 6
Part-time IT jobs in Romania and Hungary

	Romania			Hungary		
IT jobs	**On-site**	**Remote**	**Hybrid**	**On-site**	**Remote**	**Hybrid**
Software Engineer	8	2	0	16	4	2
Senior Software Engineer	1	1	0	1	0	0
Java Software Engineer	0	1	0	0	2	0
Javascript Developer	0	1	0	0	1	0
Back End Developer	0	1	0	0	3	0
DevOps Engineer	0	0	0	0	0	0
Full Stack Engineer	0	1	0	2	2	0
Total	**9**	**5**	**0**	**19**	**12**	**2**

Romania (normalized): numbers divided by population rate 1.98 and rounded

The number of part-time job open positions is negligible compared to full-time job opportunities. The part-time IT software jobs are 121% higher in Hungary. Hungary has many more Software Engineer part-time open IT software jobs.

4 New Perspectives and Observations

Looking more broadly, there are regional distinctions to consider when comparing these two nations. Public funding and infrastructure improvements can have a profound effect on economic growth and job markets. This is where distinct variations between Romania and Hungary come into play, necessitating a closer examination. While economic metrics are relevant, demographics also play a significant role in shaping a labor market. A younger population may have more leeway and adaptability, which can be valuable, in rapidly evolving domains, such as Information Technology.

Teleworking is becoming increasingly popular in both Romania and Hungary, but disparities in company culture and attitudes may affect this trend. Our investigation into job opportunities using LinkedIn revealed a considerable gap in IT and engineering positions between the two countries, attributed to technological advancements and local markets. Interestingly, the demand for IT and engineering sectors is greater in Romania, while Hungary demonstrates a more flexible approach to teleworking and part-time positions, which could explain sector-specific differences. With the rise of the "gig economy", there's a possibility that the current negligible number of part-time positions in comparison to full-time ones may become a thing of the past. Such conjecture is fueled by data indicating a shift in this dynamic down the line.

Job-specific differences can also have an impact on education and training. In Romania, it may be worth strengthening IT training, and in Hungary, electrical and electronics engineering programs. In both countries, such a development could help fill higher value-added jobs. The positive correlation between the labor market and economic growth suggests that the development of coordinated economic policy and education strategies would be ideal for sustainable development.

Conclusions

The benefits of digitization are obvious, but there are also risks. Human resources specialists, together with the company's management, must redesign their strategy, roles, activities, and structure so that employees do not feel the absence of direct interaction and ensure a work environment and an organizational culture based on sound values and principles. In addition, due to the rapid development and change in the field of programming, it is necessary to select the most suitable technology for the development teams in order to achieve the most efficient, effective and long-term development possible [15] [16].

Employers also need to implement clearly defined internal systems, procedures, and internal policies regarding remote work to prevent legal or organizational discrepancies in the work schedule of employees.

Many new subfields of software engineering have been identified in the process of research and data collection, such as: business process automation, data analytics,

machine learning, cloud engineering, which involves in addition to knowing a programming language, many of other tools, frameworks and platforms, for the candidate to meet the requirements of the job offered.

In conclusion, the future of Human Resources (HR), will be shaped by digital transformation and, given the changing structure of the workforce, digitization and automation are becoming key components in managing labor relations. But to ensure full success, in this regard, it is equally important that human resources and pay specialists receive training and support from decision-makers in implementing the necessary changes. The work team of a department, or organizations, depends on the work of the human resources team. The effort made in several directions of promotion and advertising can bring medium- and long-term benefits for companies.

The digital transformation and the development of labor market competences in higher education is not only the responsibility of educational institutions, but also requires alignment with current industry trends and future projections. Just as human resources and corporate management are increasingly relying on digital tools and strategies to engage employees and manage teleworking, so too educational institutions need to adopt a multidisciplinary approach [17]. This includes technological adaptation, developing people-centered skills and understanding legal and organizational frameworks. The aim is that students are not only professionally prepared, but also equipped with a complex set of skills, to meet the dynamically changing needs, of the new and evolving labor market.

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Opportunities for Improving the Quality of Education and Pedagogical Teacher Training, within an International Context

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*Abstract: In this paper, the authors point out the importance of high-quality teacher training, as well as some opportunities for its improvement in an international context. They deal with the current situation and present their views on the discussed field. The paper also presents the activities of the International Society for Engineering Pedagogy IGIP. The authors deal with the issues of teacher training carried out within the international Erasmus+ project **ENTER - E**ngineeri**N**g educa**T**ors p**E**dagogical t**R**aining. Based on the Standards issued by the Slovak Accreditation Agency, it can be stated, that for teachers, it is necessary to develop their vocational, language, pedagogical and digital skills, as well as any of their transferable competencies. In the paper, the outputs and other planned intents, related to the realization of pedagogical teacher training, are introduced. In addition, pre-service teachers' opinions on the realized activities and the offered courses are presented, and recommendations for the teaching practice are formulated.*

Keywords: teacher; pedagogical teacher training; IGIP; project ENTER

1 Pedagogical Teacher Training

As Turek claims [25], teachers are among the decisive factors in the educational process, which was also clearly declared by Ušinskij (1948, p. 62) – no organizational rules or curriculum, no artificial mechanism – irrespective how well invented, can replace personality in education. Without a direct contact between educators and their mentees, no real education penetrating the character is possible. Only a personality can have an impact on personality development and determination. One's character can only be shaped by another character.

Tabak et al. [23] point out that teacher training programs, which maintain the goal of increasing the quality and professional development of teachers, have frequently been discussed. Prospective teachers' expectations of and concerns about the future may provide important information for teachers' professional development as well as the design of teacher training programs. Questions regarding how teachers prepare for effective education and training [2] [9] [13], how they create a professional identity for themselves [3] [10] [17] [20] [23], and, ultimately, how they struggle to transfer their knowledge into practice for their students [7] form the basis of many studies focusing on various aspects of the field. In the new century, answers are sought to the questions of which skills are required for individuals to succeed and which professional competencies teachers should have so that they can transfer these competencies to their students [12] [19].

We agree with Driensky [5], who claims that teachers are and have always been the most important determinants of the educational process. They can perform their important role only if they are capable of leading their students effectively not only towards professional but also personal competencies. Therefore, the job of a teacher requires high professional and pedagogical erudition [5].

A continuous improvement in the quality of education and increasing teachers' quality can be considered important [1-11] [8-22].

At universities, in many cases, it comes to a situation when there are renowned professionals who have not taken part in pedagogical training. Such a situation motivates us to the realization of activities which can increase the quality of pedagogical teacher training.

2 Selected Approaches Focusing on Improving the Quality of Education and Increasing University Teachers' Quality

In the following part of the paper, we will deal with selected approaches and activities in the context of university education quality assurance and increasing university teachers' quality. We point out the activities and the importance of the International Society for Engineering Pedagogy IGIP and the activities carried out within the project EngineeriNg educaTors pEdagogical tRaining – ENTER. We actively participate in the above activities and we believe that they are beneficial for university education quality assurance both in Slovakia and abroad.

2.1 International Society for Engineering Pedagogy IGIP

We agree with Turek [25] who claims that if teachers want to perform their tasks effectively – to educate and to develop their students' personalities – they must possess sufficient knowledge in the field, have good pedagogical training and high general culture. They should have high-quality professional training, as well pedagogical and general education. Considering the above, we focus on the activities and the importance of the International Society for Engineering Pedagogy IGIP.

The International Society for Engineering Pedagogy IGIP (Internationale Gesellschaft für Ingenieurpädagogik, International Society for Engineering Pedagogy) was founded in 1972 at the University of Klagenfurt (Austria) by Adolf Melezinek. Establishing an engineering pedagogy was a step forward at that time, engineering and pedagogy had never been linked before on a scientific level. Even in the seventies of the 20th Century European integration and standardized profiles for educators were seen as most important factors of education, training and learning [15]. Engineering pedagogy is a frontier scientific discipline, which transforms pedagogical and psychological knowledge to the field of technical sciences with the aim to increase the didactic efficiency of engineering education. The subject of engineering pedagogy is formed by knowledge necessary for a rational training of teachers of technical subjects who will educate future engineers. Education is understood in its broader sense as it does not exclusively deal with didactic questions but also pays attention to upbringing [4]. IGIP promotes scientific research, coordinates and supports international initiatives and activities in the field of engineering education [14].

The International Society of Engineering Pedagogy created an international register of engineering educators Register ING-PAED IGIP – which since then guarantees minimum standards in technical expertise and a well-balanced competence profile for engineering educators. The register lists qualified

educators who had gone through an IGIP prototype curriculum. Those registered are International Engineering Educator and can use the title ING-PAED IGIP [15].

The existence of the Register as well as the degree ING-PAED IGIP – in general – have a positive impact on technical subject teachers' social status. In states, where IGIP operates (currently more than 70 countries including most EU Member States), the degree means that a person is qualified for teaching technical subjects [16]. IGIP accredits training centers for "International Engineering Educators" which conforms to IGIP's curriculum for engineering pedagogy [15]. In Slovakia, the first information about engineering pedagogy were mediated by professor Dušan Driensky who was appointed to the international IGIP Scientific Advisory Board in 1986 and in year 1993, he established the Slovak IGIP national working group in Bratislava [4]. Currently, the Slovak section of IGIP is based at DTI University in Dubnica and Váhom.

2.2 The EngineeriNg educaTors pEdagogical tRaining Project – ENTER

The EngineeriNg educaTors pEdagogical tRaining - ENTER project is being solved as a part of the Erasmus+ program – key activity Cooperation for innovation and the exchange of good practices. The project intent is based on the situation, when teachers of engineering majors often have broad and solid expertise in their subject field but lack pedagogical competencies relevant to the modern learning environment. Higher education teachers and lecturers should have such pedagogical competencies which enable them to implement key educational approaches of the 21st Century [1].

The main goal of the project is to develop a multilevel modular system for pedagogical teacher training – the program ENTER iPET, which will be based on international collaboration. The project is focused on university teachers and takes into account their needs (low cost, convenience, mutual recognition, peer-reviewed quality assurance, customization), aims to greatly increase the number of engineering educators enrolled in pedagogical and professional improvement programs. This will have a profound impact on the quality of university education in ENTER member higher education institutions, but later, on universities in the whole European Union. i-PET program accreditation is also one of the project's objectives.

The ENTER proposes a hierarchy of 3 structured educational programs for engineering educators - iPET program, in the context of the European Qualifications Framework for Lifelong Learning:

- iPET-1 Short-focused (2 ECTS) – "Qualification Development" Certificate
- iPET-2 Professional Retraining (8 ECTS) - Diploma "Higher Education Teacher"

- iPET-3 International recognized (20 ECTS) - a full program leading to international accreditation as “Engineering Educator” [5]

The aim of the project is to ensure that iPETs meet the European standards for the quality of education in engineering study programs.

In the following part of the paper, we introduce the outputs and intents of the international Erasmus+ project **ENTER** – **E**ngineeri**N**g educa**T**ors p**E**dagogical t**R**aining, as well as the proposed courses.

3 Concretization of Outputs, Intents and Proposed Courses within the ENTER Project

The ERASMUS+ ENTER (**E**ngineeri**N**g educaTors p**E**dagogical t**R**aining) project was set up by a consortium of HEI’s and Accreditation Agencies from Europe, Russia, and Kazakhstan. The main idea of the ENTER project is to build the capacity of engineering HEIs due to the strengthening of engineering educators’ preparation with innovative engineering pedagogy. Because of this particular sort of educator’s concerns to such a specific field that has a high impact on scientific progress and innovative development of humanity it is very important how the teaching and learning processes are organized and what is the content and teaching methodology. That has a great impact on the potential quality of learning outcomes of future engineers and consequently on the industry and economic development. The innovations of the 3-tiered training programs (i-PET programs) meet the needs of the engineering educator’s pedagogical development [18].

ENTER Consortium consists of the following institutions:

Project Coordinator

- Instituto Politecnico do Porto, Portugal

European partners

- DTI University, Slovakia
- Tallinn University of Technology, Estonia

Russian and Kazakh partners

- National Research Tomsk Polytechnic University, Russian Federation
- Kazan National Research Technological University, Russian Federation
- Tambov State Technical University, Russian Federation
- Don State Technical University, Russian Federation
- Association for Engineering Education of Russia, Russian Federation

- Al-Farabi Kazakh National University, Kazakhstan
- Academician E. A. Buketov Karaganda State University, Kazakhstan
- Kazakhstan Association of Engineering Education, Kazakhstan
- Vyatka State University, Russian Federation
- Association for International Education Support «Bologna Club», Russian Federation [5].

The proposed structure of educational programs for teachers including individual modules is displayed in Table 1.

Table 1

Structure of iPET educational programs

Program	Course	ECTS
iPET-1 (2 ECTS)	1.1 Innovations in engineering pedagogy	1
	1.2 Time management	0.5
	1.3 Effective interaction	0.5
iPET-2 (8 ECTS)	2.1 Enhancement of learning interactivity	1
	2.2 System analysis in education	1
	2.3 Pedagogical psychology and communication	1
	2.4 Interaction with stakeholders	1
	2.5 Sustainable development	2
iPET-3 (20 ECTS)	3.1 Digital education	2
	3.2 Problem-based, Project-based and practice-oriented learning	2
	3.3 Learning outcomes´ assessment	2
	3.4 Course design	1
	3.5 Engineering innovation process	2
	3.6 Final project	3

Note: The modules of iPET-1 are included in iPET-2 and those are included in iPET-3

Source: Project EngineeriNg educaTors pEdagogical tRaining - ENTER

Throughout the process of project realization, two main parallel processes take place – developing the iPET program and developing the quality management standards for the iPET program. The above is displayed in Figure 1.

The goal is to ensure that iPET educational programs meet the European quality standards for education in engineering studies.

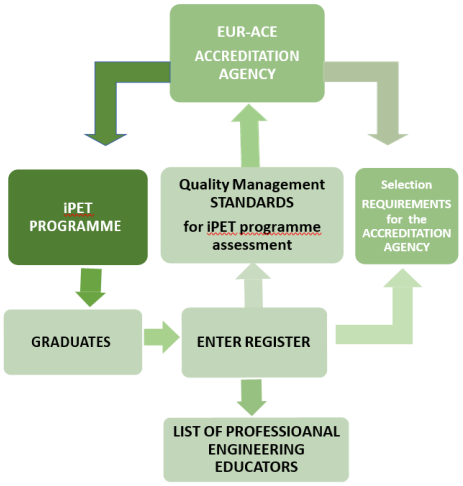

Figure 1
Development of the iPET program and development of quality management standards for the iPET program [6]

4 Feedback on Education Quality and Teacher Quality Assurance

For the purposes of research and gathering feedback on the quality of education and teacher quality, a range of tools can be used. In the paper, our intention is to point out some verified examples of good practice.

Students form an important interested party in a university and, therefore, their opinions can be considered very important. Students belong to the main actors in the school environment and by finding out about their opinions, universities can gain information necessary for university education quality and teacher quality assurance.

The significance of students' opinions is reflected in the criteria for the assessment of conformity between the internal system of a university and the standards for the internal system, and the criteria for the evaluation of standards for a study program.

In compliance with the Standards issued by the Slovak Accreditation Agency for Higher Education, students are provided with an opportunity to comment on the quality of study programs, the quality of teachers, the quality of support services and the quality of the university environment at least once a year. Gathering relevant feedback from all interested parties forms a part of monitoring and

evaluating processes of a study program. Students can also comment on the quality of teaching and the work of teachers in a study program at least once a year by means of an anonymous questionnaire.

In the context of the above criteria, we have good experience with collecting anonymous student feedback after each semester (twice a year) by means of an anonymous questionnaire using the university's academic information system, in our case it is the Modular Academic Information System (MAIS) and we find it beneficial. The above example of good practice and the obtained results are specified in the following part of the paper.

4.1 Student Feedback in the Modular Academic Information System MAIS

An opportunity for gathering student feedback by means of an anonymous questionnaire is offered by using the Modular Academic Information System MAIS. Students complete the questionnaire twice a year (after each semester). The anonymous questionnaire is oriented on several fields, within which the following information are examined in details:

Part 1: Content of the subject and its implementation in the study program:

In this part, we examine students' opinions on the **significance of the** subject for their profile in the study program, on **including the subject** in their study plan, and **the interconnectedness** between subjects, opinions on **meeting the goals of the subject** from the students' point of view, on the **content of the subject in relation to their expectations**, students' opinions on the **extent of teaching considering the number of credits,** and students evaluation of the **time distribution of lectures** and the **time distribution of seminars**.

Part 2: Organization of the educational process:

Students' evaluation of **teachers' adherence to the timetable, adherence to the syllabus,** their opinions on **supplementing teaching time by consultations by teachers** and their opinions related to the current situation in **implementing e-learning in a particular subject** are investigated into.

Part 3: Performance assessment:

Students indicate whether they are **sufficiently informed about the assessment criteria,** whether the **assessment by teachers** is objective, they comment on formative **assessment of knowledge during the semester** and to **teachers' approaches to students' objections.**

Part 4: Staffing of the subject:

In this part of the anonymous questionnaire, students' opinions on the **teacher's expertise,** on the **clarity and comprehensibility of lectures, the teacher's**

creativity, how the teacher **motivates and develops students' activity during lectures**, how students evaluate motivating students by the teacher**,** and their opinions on creating **space for discussions** by the teacher are investigated into and an opportunity to express their **own opinions** is provided**.**

Part 5: Availability of resources:

In relation to resources, we are interested in whether – according to students – the **recommended literature corresponds with the content of the subject,** what is **the quality of study materials provided by teachers,** how students evaluate the **availability of recommended literature**, and students are also asked about the **availability of resources in the university library**.

Part 6: Teaching - forms, methods:

Students express their opinions on the issues of the **diversity of applied methods of teaching**, **systematicity – the logical continuity of the provided information** in a particular subject, on the **interactivity of education – students' active participation, demonstrations – using examples from practice and case studies, application of a scientific approach – integration of modern scientific knowledge and research into the subject content,** durability – **consolidating theoretical knowledge during seminars** and **practicality – existence of a link between the gained knowledge and practice.**

Part 7: Spatial and technical equipment:

In this part, we examined students' opinions on **classroom premises and equipment, using audio-visual devices** in the course of the educational process of a particular teaching subject, **application on modern digital teaching devices**, **using professional software during lessons**, and we were also interested in the evaluation of **internet access** by students.

Part 8:

The last part of the anonymous questionnaire provides students with space for **mentioning the most serious issues related to their studies**, making proposals for improvement, and commenting on what could increase the quality of education.

In the anonymous questionnaire, students indicate their opinions on a scale: Excellent - 1, Very well - 2, Well - 3, Sufficient - 4, Insufficiently - 5.

In the questionnaire, the following information are identified: subject, teacher, students' gender, form of study, level of study, year of study.

The data obtained from student feedback are among the observed components of the internal system of university education quality assurance by the management, which is a guarantee for considering them and for their application for the purposes of quality assurance.

Alongside with that, we recommend to provide the heads of departments with the obtained information in order to use them for the purposes of subject quality assurance in their department.

Another tool, which proved itself valuable to is in gathering feedback, is internal audits.

4.2 Feedback from Internal Audits of Ongoing Processes at the University

The goal of internal audits in the school is to assess the conformity level between the processes and the documentation of the internal system of university education quality assurance, and the ISO 9001:2015 requirements (as DTI University works in accordance with that norm); to assess the efficiency of the internal system; and to improve the internal system and its documented procedures. We consider internal audits an important tool for university education quality assurance. We find it important to monitor the results of internal audits and to be interested in new trends. We present the current results, as well as the results for previous periods since the introduction of the internal system, and we also pay attention to the trends.

4.2.1 The Trend in the Process of Education according to the Results of Internal Audits

The results of internal audits of the process Education with the trend line are displayed in Figure 2.

Trend line equation: $y = -0.3697x + 98.661$

Reliability equation: $R^2 = 0.527$

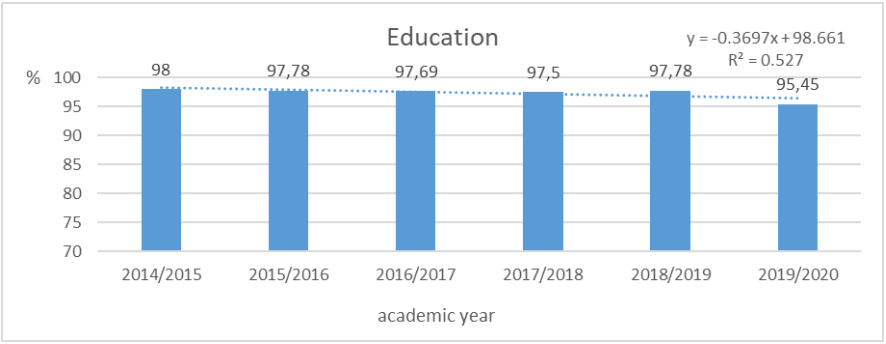

Figure 2
Results of internal audits of the process Education with the trend line

4.2.2 Trend in the Process Employee Quality

The results of internal audits of the process Employee Quality with the trend line are displayed in Figure 3.

Trend line equation: $y = 4.3563x + 74.258$

Reliability equation: $R^2 = 0.8706$

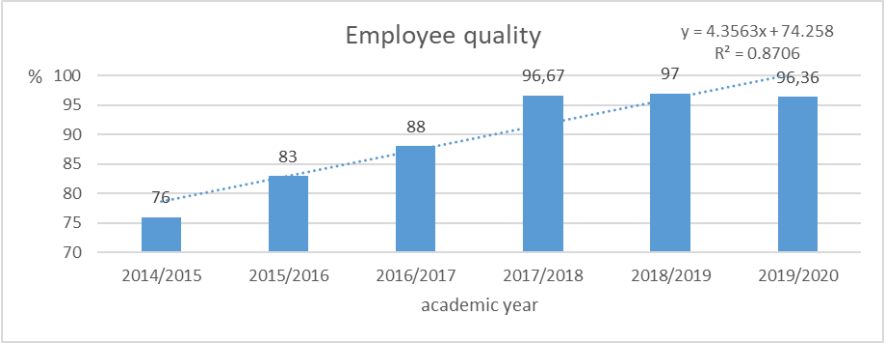

Figure 3
Results of internal audits of the process Employee Quality with the trend line

4.3 Feedback on the Realized Meetings and the Proposed Courses within the International Erasmus+ Project ENTER

In the course of the realization of the project, we were interested in DTI University students' perception of the activities carried out within it and in what their opinions on the provided courses are. We addressed third-year students in the study program Teacher Training in Practical Training.

Within the investigation, students were asked to select one of the realized project meetings (www.erasmus-enter.org, part Project Meetings) and describe what they liked about it. They were also asked to select three out of the fourteen suggested courses based on their importance (those which teachers should complete) and comment on why they find them the most important. Taking into account the extent of the paper, we present an overview of the most important findings.

The selection of meetings by students within the **ENTER** project is displayed in Table 2.

Another 27.03% of students commented on meetings without any specification of the meeting.

Table 2
Selection of meetings by students within the ENTER project

ENTER project meeting	**Dates**	**% of students**
Kick-off meeting and Preparation (Porto, Portugal)	15th January – 18th of January, 2019	10.81
WS1.1 - Workshop on ENTER structure and operation, WS1.3 - Workshop for developers' group (Tambov, Russian Federation)	29th May – 31st May, 2019	16.22
WS1.2 - Workshop on ENTER QMS and procedures WS2.1 - Workshop on iPET course development (Almaty, Kazakhstan)	18th September – 21st September, 2019	10.81
WS2.2- Workshop on iPET modules' contents (Bratislava, Slovakia, online)	22nd April – 23rd April, 2020	32.43
TR1.1 - Training of management staff on QMS (Rostov on Don, Russian Federation, online)	1st July – 3rd July, 2020	2.70

In Table 3 students' ranking of the proposed courses based on their importance are displayed (students were asked to select three out of fourteen courses based on their importance).

Table 3
Students' opinions on the significance of courses

Program	**Course**	**% of students**
iPET-1 (2 ECTS)	1.1 Innovations in engineering pedagogy	18.92
	1.2 Time management	29.73
	1.3 Effective interaction	45.95
iPET-2 (8 ECTS)	2.1 Enhancement of learning interactivity	35.14
	2.2 System analysis in education	13.51
	2.3 Pedagogical psychology and communication	48.65
	2.4 Interaction with stakeholders	5.41
	2.5 Sustainable development	2.70
iPET-3 (20 ECTS)	3.1 Digital education	43.24
	3.2 Problem-based, Project-based and practice-oriented learning	8.11
	3.3 Learning outcomes´ assessment	8.11
	3.4 Course design	0.00
	3.5 Engineering innovation process	2.70
	3.6 Final project	0.00

8.1% of students did not specify the courses when commenting on it. The participating students were most interested in the following courses: Pedagogical psychology and communication (48.65%), Effective interaction (45.95%) and Digital education (43.24%).

We are pleased by the fact that students showed interest in the project and courses during the investigation, and they commented on the project and the courses. In the upcoming period, we will continue with other planned activities. Due to the pandemic situation, the project period was prolonged by one year, the project will finish in November 2022. Our ambition is to continue with the activities related to improving the quality of education and the quality of university teachers even after the project ends.

Conclusions

In the conclusion, our recommendations for the pedagogical practice in relation to improving the quality of education and the quality of pedagogical teacher training are listed. In order to meet the criteria, teachers must develop the above skills and competencies necessary for the provision and development of study programs, and the university should have evidence of it in the form of documents (e.g., certificates).

In the context of the above requirement, there is a wide range of options for meeting them (e.g., courses and seminars). We would like to point out three of them, which can be well applied both in Slovakia and which we consider significant in relation to university education quality and teacher quality assurance, and which are also related to the above-described realized project activities. The three options are:

Courses developing university teachers' pedagogical competencies: We encourage university teachers to take part in courses developing their pedagogical competencies, particularly programs providing pedagogical psychological training for university teachers in compliance with the requirements of the International Society for Engineering Pedagogy IGIP. The graduates of such courses for university teachers are entitled to request the international ING-PAED IGIP certificate.

Joining the ING-PAED IGIP Register and earning the degree of ING-PAED IGIP: Completion of pedagogical studies and earning the degree of ING-PAED IGIP is a means of improving the quality of teachers, i.e., also of university education quality assurance. Alongside with that, earning the degree of ING-PAED IGIP has a positive impact on the status of teachers as well.

ENTER project courses: The ENTER project, focuses on developing a new multicultural and international approach for formal post-gradual vocational and pedagogical teacher training – the ENTER iPET program. The ENTER iPET project is oriented on e-learning technologies and its ambition is to become internationally accredited. It proposes a hierarchy of three structured

educational programs for teachers in the context of the European Qualifications Framework for Lifelong Learning. We recommend university teachers' participation in educational programs, which provide opportunities for the development of their skills and competencies, increasing their quality and also the quality of university education.

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Supporting the Pedagogical Evaluation of Educational Institutions with the Help of the WTCAi System

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Abstract: One of the main aims of educational institutions, is to prepare children for further education and successful integration into the workforce. To achieve this, as much as possible, it is necessary to meet the requirements and expectations set by dynamically changing economic and social environments. Research has shown that learner-centered knowledge transfer and a constructive pedagogical approach have proven more effective in achieving all possible learning outcomes than cognitivist learning theory (teacher-centered education). Therefore, pedagogical monitoring and evaluation procedures are necessary and integral parts, of the educational process, with the goal not only being performance evaluation but also improving and supporting the learning process. Then again, a sad characteristic of the current system is that, on the one hand, it needs to support individual learning paths adequately and on the other hand, the validity of measuring tools suffers, due to the generation gap between teachers and children. Therefore, the development of pedagogical monitoring and evaluation processes, should be an integral part of the constant improvement of educational institutions. Consequently, the question arises: How can the pedagogical monitoring and evaluation system be developed, so that individual learning paths are supported and the validity of measurement tools is optimally ensured? In seeking the answer to this question, our research aims to develop a complex evaluation system, supported by artificial intelligence (WTCAi - When The Child Ask with AI), that suggests suitable actions for monitoring and evaluation, for subject teachers.

Keywords: pedagogical monitoring; evaluation; individual learning paths; validity; learner-centered knowledge transfer; development of monitoring and evaluation systems; WTCAi; item; generation gap; artificial intelligence; machine learning

1 Introduction

A school should be able to prepare students for adult life and successful integration into the labor market while maintaining the educational process at a minimum level, taking into account the changes in the surrounding world, the current economic and political situation, and all other circumstances that require an immediate and appropriate response. This is certainly not an easy task, but it is not entirely impossible [1]! Contemporary teaching-learning environments [27], such as self-learning, experiential learning, free independent learning or even on the job training, require new strategies, i.e., tools, resources and resources and tools that are inevitable to access new knowledge [15].

One of the most important ingredients is the so-called "learner-centered" approach to knowledge transfer, in which, similar to the teacher-centered approach, the leading educator determines the general parameters, goals, knowledge, and skills to be acquired and evaluates them. The difference lies in the fact that, unlike teacher-centeredness, students are no longer merely passive recipients and repeaters of information but assume much greater responsibility for their own curriculum and learning. In this form, the instructor does not function as the exclusive source of wisdom but rather as a coach or leader whose primary task is to assist students in acquiring the desired knowledge, competences (digital) [23] [29], and skills for themselves. Today, the existence and development of digital competences is becoming increasingly important, as described in several EU frameworks [22, 24, 28]. They are also becoming increasingly important in teacher education [26]. Weimer's research has shown that learner-centered education proved to be superior in achieving virtually every possible learning outcome compared to teacher-centered teaching [2] [3].

The key indicator of the quality assurance system level in education and training is provided by the process of monitoring and evaluation. Pedagogical evaluation is an integral part of every educational process. An important part of the ICT tools is knowledge assessment systems, which measure the cognitive performance of students [14, 26, 29, 30]. The education and training system can only function effectively if the teaching and learning process is constantly monitored, evaluated, and reviewed. This illuminates the necessary intervention points clearly and unambiguously. The timely, appropriate, and adequate intervention is a fundamental pillar of a well-designed and operated evaluation system.

Every educational institution must ensure proper planning and implementation of the evaluation and assessment process. This assessment system must consider the various needs and abilities of the learners and support the learning process, with particular attention to individual learning paths. The purpose of evaluation and assessment is not only to evaluate performance but also to improve and support the learning process.

2 Challenges of Pedagogical Evaluation

Children's first level of education and upbringing occurs in primary institutions. These institutions play a prominent role in the education system, as they not only provide the basic knowledge and skills that form the foundation for further education and career development but also focus on developing personality traits that are most malleable at this age. As we have seen, monitoring and evaluation are essential elements of the pedagogical process, contributing to effective and quality education and training. Pedagogical evaluation permeates every level of the teaching-learning process, appearing in various forms such as oral, written, and practical tasks, tests, and exams. Of course, teachers are free to exercise their pedagogical autonomy, which obviously extends to monitoring and evaluation processes. Within an institution, teachers who teach the same subjects ideally develop item sets for performance assessments (see professional work) groups along a common line. In addition, various centrally designed topic closing questionnaires (see national core curriculum and framework) are available for each subject - although not for all - which are often not used by instructors due to suspicions of cheating, as anyone can obtain these through other means. From all of this, it is apparent, visible, and experienced firsthand by many that pedagogical evaluation, despite the best intentions of subject teachers, often leaves something to be desired [20] [21] [38]. Regarding the current system, we can certainly highlight two significant findings:

- The assessment and evaluation process needs to be learner-centered for all students and uniformly support individual learning paths.
- When determining the performance assessment items, the subject teacher thinks with their own 'adult head' due to their age, which fundamentally shapes the entire process of monitoring and evaluation.

2.1 The Characteristics of the Evaluation System

To fully understand the impact of these two factors on the entire pedagogical evaluation process, we need to examine the characteristics of the evaluation system itself. Evaluation is a highly complex process, as evidenced by the numerous definitions that attempt to reflect the procedure's complexity. The evaluation is fundamentally influenced by the goals to be achieved, but it is also necessary to mention that new challenges have emerged in connection with learning:

- The revaluation of the role of knowledge transfer in learning
- Preference for new skills and abilities in the world outside of school
- An educational environment that better suits individual needs
- Respect for individual development

- The teacher as a learning support partner
- The responsibility of the learner for their own learning process
- Learning environments that challenge students
- The importance of usable knowledge and knowledge building
- The development and importance of competencies
- Lifelong learning
- Confirmation of students' strengths by their peers. [3] [4] [30] [31]

At the same time, new challenges have also emerged for teachers, partly due to changes in the perception of children (heterogeneous groups of children; sociocultural differences; equality, equal opportunities, and creating opportunities) and partly due to the explosion of information and the advent of cutting-edge technology (huge amounts of information; practical knowledge, new competencies; modern communication tools) [5] [39].

The educational direction that emerged as a result of these changes involves the application of constructivist pedagogy and related teaching methods, where:

- The learner does not simply absorb knowledge
- Knowledge is not simply conveyed
- The learner creates knowledge on their own, constructs it within themselves
- Learning is based on prior knowledge
- If new information does not fit or contradicts their existing knowledge system, a conceptual shift occurs, leading to a certain degree of transformation of the knowledge system [6]

2.2 The Possibilities of Constructivist Pedagogy

The emergence of online education has provided opportunities for the widespread adoption of tools and methods that can significantly support constructivist pedagogy. Examples include blended learning, the use of e-learning materials, and platforms that offer complex services to support these approaches. With these systems, learners can be provided with the opportunity to learn at their own pace, practice certain aspects multiple times, and master the material. One of the most significant features of constructivist pedagogy is effective learning organizing method [16-18]. Feedback on progress and evaluation provide measures of effectiveness and success. In evaluating performance, we always compare it to something. The individual learning paths would be complete if the evaluation were also conducted about these paths. Following the internal aspects of education, the assessment would focus on the increase in knowledge during the specific period.

Let us examine why and how the fact that only the "adult" mindset of the subject teacher or teachers participates in creating the items needed for assessment affects the entire process.

Assessment and evaluation play a critical role in helping individuals find their place. Therefore, it is extremely important that evaluation is accurate, reliable, and inclusive of changes! The goal of educational evaluation is personality development, and the basis of evaluation is student performance. However, student performance is constantly changing and determined by psychological, educational, and social factors. Assessment and evaluation are necessary because, on the one hand, the lack of feedback is detrimental, and on the other hand, it shows the degree of success and the extent of falling behind, and it also improves performance. However, the prerequisite is that the evaluation should be objective and valid, among other things. Objective evaluation is a condition that must be personal, developmental, and motivational. Validity is achieved when we measure exactly what we intended to measure during the assessment. This can typically be handled as a communication issue. A task often does not focus solely on the targeted area. One of the most common problems in planning written assessment and evaluation is that the student solving the task may interpret it differently or not understand it due to their reading comprehension skills. In this case, the unsuccessful solution of the given-task is caused not by a lack of subject-specific knowledge but by the misunderstood task and communication problem [6-8] [32].

Proper evaluation contributes to the development of different values, norms, and behavior patterns, motivates learning, and provides a model. It objectively develops self-image, strengthens, provides a model, and predicts. However, if we do not measure what needs to be measured or do not measure it correctly, it will push all of these evaluation functions in the wrong, negative direction and will not trigger the appropriate personality development effect. The teacher's "adult" way of thinking can unintentionally contribute to this evaluation error by phrasing differently or placing emphasis elsewhere due to generational differences [33] [35-38] [40-42].

3 The Description of the Research

Educational institutions should consider the proper functioning and continuous development of their monitoring and evaluation systems as a top priority for their educators in order to ensure the effectiveness and success of the teaching and learning process. It is particularly important, therefore, that not only the tools and methods of the educational process but also the pedagogical evaluation processes necessary for measuring effectiveness are constantly evolving and adapting to current expectations.

3.1 The Aim of the Research

The main objective of our research is to increase the efficiency of pedagogical evaluation processes implemented by educators in educational institutions through the development of a machine learning-supported complex evaluation system (WTCAi - When The Child Ask with AI), which suggests adequate items for control and evaluation to the subject teacher. During the process, students can formulate and compile their own accountability questions related to the topic or lesson content, from which the WTCAi system, using the possibilities of machine learning and artificial intelligence based on the knowledge already acquired by the age group, automatically compiles and suggests question sets for the subject teacher for evaluation.

Additional objectives related to the main research area are:

- Maintain the constructivist pedagogy approach, the system can support individual learning paths by automatically generating personalized questionnaires.
- Automatically generated questionnaires should be structurally and grammatically accurate, requiring minimal human correction.
- Develop the children's ability to summarize and organize information.
- Improving the children's grammar skills.
- Enhance the children's creativity and self-awareness.
- Help the teacher understand and tune in to the "frequency" of the age group.
- Providing feedback to the teacher about the level and depth of understanding of the taught material, enabling them to adjust the teaching process in a favorable direction based on feedback.

3.2 Brief Introduction of the Research

Our research aims to promote the comprehensive development of students through the use of various teaching methods in the process of developing STEM skills. One of the methods applied in our discussions was the questioning-and-explaining approach, which stimulated students to ask relevant questions in order to solve a given problem. Transactive discussions in which the students operate elaboratively on each other's metacognitive regulation seem to be facilitative and supportive [18].

3.2.1 A Brief Overview of the Research Process

During the educational process, teachers deliver lessons based on a previously prepared curriculum, following the regulations outlined in educational documents. To achieve the goals of a given lesson, teachers determine the most suitable tools and methods beforehand. Periodic pedagogical control and evaluation occur during the classes, following a predetermined curriculum to ensure students have mastered the material. Evaluation involves analyzing collected data and comparing it to a predetermined standard. Teachers use assessment tools tailored to the evaluation's purpose, either creating them themselves or using a centrally prepared version. Regardless of which method the teacher chooses, one factor remains constant: the age difference between the teacher and the students. This age gap significantly affects communication efficiency and mutual understanding. As teachers' average age increases in Hungary and fewer newcomers enter the profession, the generational gap widens, leading to communication difficulties. “The discrepancies between generations are often due and strengthened by the different communication of two generations. As long as a generation is being educated and served by the previous generation, this education will be responsible for any issues with the new generation.” [17] The generation gap also affects young professionals who are starting their careers. Additionally, communication problems can arise if a teacher's communication skills are lower than necessary.

The evaluation and assessment processes provide feedback on the effectiveness of teaching and learning processes. The results of a measurement can only be used to regulate teaching and learning if the measuring tool (the measurement) meets the requirements of objectivity, validity, and reliability. Communication misunderstandings caused by the generational gap or inadequate communication skills jeopardize the validity of measuring tools, and violating this endangers the usability of the results! In order to avoid this, we must create a connection between the children's and the teacher's way of thinking. From the child's perspective, we currently have very little feedback in the area of measuring tools. In many cases, it can be observed in classes that things that are clear to adults are approached by children from a completely different perspective.

Let's take a short illustrative example: one of the questions in a questionnaire prepared for third-grade children aimed at understanding the Creative Commons License and it was: *What is the Creative Commons License?* For most third-grade children, this question was simply incomprehensible, and many were even scared of it. After a brief explanation by the teacher, relieved "ohh" sighs could be heard, and they started answering the question. After that, we asked the children to formulate a question that they expected the discussed answer to. So, they came up with the following question: How does the Creative Commons License work? As we can see, there is a relatively small difference, but from the children's perspective, it means something entirely different. For them, the rephrased question was the one they could answer without fear, and that covered the

requested answer. Therefore, the original question, *"What is the Creative Commons License?"* received the answer, *"Well, that's the Creative Commons License."* In contrast, the question *"How does the Creative Commons License work?"* describes what needs to happen.

Another example we can mention for illustrative purposes is when a primary school student with mild autism, who is talented in programming, asked the following question in Hungarian literature class: *What is a poetic letter?* The child could not interpret the question because, for their generation, the first association with the word "letter" is not the traditional literary form of a letter but a leaf. With guidance, they eventually got to the email, which is closer to the traditional postal letter, but we must note that for their generation, email is becoming an increasingly outdated technology. Examining the psychological background of this phenomenon could be the subject of separate research, which is not part of our study. However, it can be inferred from the simple licensing example above that although we, as adults, think the two questions are aimed at the same thing, children make a significant big difference between the two.

3.2.2 The Start of the Research

We started the research by asking students to come up with five questions related to the material covered in class that they would like to ask themselves in an exam as if they were the teachers.

Data collection is ongoing, currently focusing on the topics of digital culture curriculum in three institutions, but of course, it can be extended to any other subject in the future. Based on the data and samples received, the AI-based database model will be set up. Meanwhile there is no need for prior knowledge of the data in clustering process. Unsupervised models can be trained solely using the available data without any specific labels or guidance [13].

3.3.3 Short Research Results and Experiences

Through our brief research, we concluded that based on the available data, it is already possible to determine which are the most commonly asked questions on a given topic. Our observations indicated that these questions were also the easiest to answer regarding the material, and as the popularity index of the questions decreased, the tasks became increasingly difficult. Moreover, we found that children, in general, do not avoid difficult questions, and depending on the interest of the lesson, they are capable of putting together entirely relevant assignments.

Based on our experience, we have discovered that there are many inappropriate questions due to various aspects which need to be filtered out. Our goal is to produce question sets that are differentiated and meet all the requirements of the evaluation tool. We must ensure that the child has asked a question - or whether they have instead given a task -whether they formulated the question

grammatically correctly, and fact that the children are very diverse in terms of their personalities, so a fundamentally similar question can be formulated in many different ways. At the beginning of our experiments, we found that with a simple *cosine similarity* calculation, we could relatively easily limit the popular question sets. In addition, by using various machine learning processes (nltk, numpy, pandas, spacy, sklearn), we can access derived data, which can be used to infer various properties of the lesson plan. By expanding data collection, we can draw further conclusions in this regard.

Our current research objective is to use artificial intelligence and machine learning to create an algorithm that can sort the easy and difficult questions on a given topic from the database we created and automatically compile a set of questions containing the number of questions determined by the teacher, from the children's questions, thereby reducing the cognitive differences that arise due to the generation gap.

3.3.4 The Examination and Analysis of the Data

The statistical analysis of available data is of paramount importance before determining and training a machine learning model. Statistical analysis can include a preprocessing phase that ensures the available data is properly structured and formatted, as well as error-free, to ensure that the machine learning model is trained with the appropriate data, leading to more relevant results.

During statistical data analysis, the following procedures are employed:

- Normalization issues
- Outlier detection
- Data distribution
- Correlation analysis

Normalization is not always necessary, and it depends on the type of data being worked with, the type of analysis being performed, and whether the chosen model requires normalization. Typically, the following cases require normalization of available data:

- Data is on different scales. For example, if one column has numbers ranging from 0 to 100, while another column has numbers ranging from 0.01 to 10, normalization can help bring the data to a common scale
- In cases of skewness, when the data distribution is non-normal, or if the data range is too wide or too narrow, normalization can help in separating the data and reducing skewness
- If the model requires normalized data, then normalization may be necessary

During extreme value analysis, Min-Max analysis can become useful if we want to place the data into the interval [0, 1] while maintaining the relative position of the data, i.e., not changing the relationships between the attributes. This way, the data becomes easily comparable. The Min-Max analysis is a type of normalization process that has the advantage of making the data easily interpretable and comparable while retaining its usefulness, thus facilitating its interpretation.

The data distribution shows us how our data is distributed and what statistical measures characterize it, such as the mean, median, variance, etc. It not only facilitates data interpretation but also plays a crucial role in one of the most important data preparation operations, problem identification.

Problem identification is one of the most critical steps in data preprocessing. The following methods can be applied during data analysis to identify possible problems in:

- **Identifying missing data:** Data should be checked for missing values.
- **Data imputation:** Various methods can be used to replace missing data, such as using the mean, median, or mode.
- **Data cleaning:** During data cleaning, we remove data that is irrelevant or erroneous.
- **Identifying outliers:** Outliers are values that deviate significantly from the general data sample. Various methods are available to identify and handle outliers, such as using boxplots or z-scores.

From the outcome of the data distribution, we can infer and filter out the issues mentioned above from our dataset. With correlation analysis, we examine the relationships between our data. The correlation between data means how one data value changes when the other data value changes. In other words, we can determine how strong or weak the relationships between the data are. Some important notes regarding correlation analysis and the resulting correlation matrix are:

- The correlation range is between -1 and 1, where 1 represents perfect positive correlation - i.e., if one data increases, the other data will also increase, and -1 represents perfect negative correlation, i.e., if one data increases, the other data will decrease.
- The absence of correlation does not mean that there is no relationship, and if the correlation is strong, it does not necessarily mean that one causes the other. Further expert knowledge is required to make these determinations.

Despite its intelligence, we should never forget that the final result generated by the chosen machine learning model needs to be examined and analyzed with critical, expert eyes since the machine only learns from data and can produce anything from it. If the formulation of the problem being examined is not

appropriately done, the related algorithm - and thus the chosen model - may not be the most suitable for the problem. Therefore, in all cases, the results obtained need to be evaluated and reviewed by expert human judgment.

In our research, the following examination tools and methods currently appear:

- Examination of Dice coefficient
- Examination of Jaccard distance
- Examination of Cosine similarity

The *Dice coefficient* is a text similarity measure that gives the ratio of common elements in two sets relative to all elements.

$$D_{a,b} = \frac{2 \mid \text{word}_a \cap \text{word}_b \mid}{\mid \text{word}_a \mid + \mid \text{word}_b \mid}$$

The result can take a value between 0 and 1, where one means that the two sets are completely identical, while 0 means that the two sets have no common elements.

Jaccard distance **analysis**

The Jaccard distance measures the ratio of the intersection of two sets to the union of those sets.

$$J_{a,b} = \frac{|\text{word}_a \cap \text{word}_b|}{|\text{word}_a \cup \text{word}_b|}$$

The result here, similar to the previous function, can take a value between 0 and 1, where one also means that the two sets are completely identical, while 0 means that the two sets have no common elements.

Cosine similarity **analysis**

Cosine similarity is the most popular method for comparing texts. It allows us to measure the cosine of the angle between two vectors in the vector space formed by the texts. The concept is that if two texts are very similar to each other, then the vectors formed by these texts point in a similar direction. For any two patterns, the patterns are considered less similar as the Euclidean distance between them increases, but they are considered more similar as the cosine similarity between them increases. [19]

$$C_{a,b} = \frac{\mid \text{word}_a \cap \text{word}_b \mid}{\sqrt{\mid \text{word}_a \mid \mid \text{word}_b \mid}}$$

The result can take values between -1, 0, and 1, where one means that the two texts are entirely identical, -1 means that the two texts are completely different, and 0 means that no vectors are pointing in the same direction for the two texts.

Code sample from the research material:

```
for sentence in sentences:
    sentence = sentence.strip()
    doc = nlp(sentence)
    sentence_scores = []
    for other_sentence in sentences:
        other_sentence = other_sentence.strip()
        other_doc = nlp(other_sentence)
        sentence_scores.append(doc.similarity(other_doc))
    scores.append(sentence_scores)
    mean_scores.append(np.mean(sentence_scores))
    variances.append(np.var(sentence_scores))
```

The user interface for a possible solution for collecting questions.:

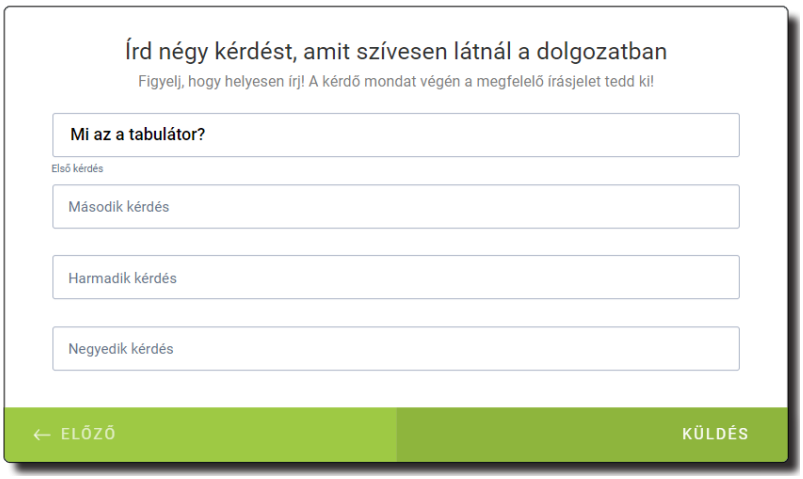

Figure 1
AI-ased user interface

The machine learning model analyzes the question the child asks based on the previously trained data and fills it with content related to the given topic. This solution enables the expansion of the thesis with literature related to the topic and can improve the quality of the thesis. In this test, for simplicity, we use a decision tree algorithm.

A Decision Tree is a tree-like model in which each node refers to a particular attribute, and the branches are linked to the values of the attributes. The algorithm moves along the branches to estimate the values of the dependent variables, making various decisions until it reaches the leaves, where the predictions are

made. The advantage of the Decision Tree algorithm in our case is that it is easy to understand, easy to apply, and does not require much preprocessing.

```
from sklearn.tree import DecisionTreeRegressor
model_dtr = DecisionTreeRegressor(random_state=42)
model_dtr = model_dtr.fit(X_train, y_train)
y_pred_dtr = model_dtr.predict(X_test)
```

Conclusions

Pedagogical evaluation is integral to any educational process, but it can only work effectively, if the teaching-learning process is constantly monitored, controlled, and evaluated. The evaluation and measurement system should consider the learners' different needs and abilities, support individual learning paths, and meet the basic requirements for measurement. However, if we measure the wrong things or in the wrong way, it can provide teachers with inaccurate data and cause negative distortions in the child's self-image. The teacher's "adult" thinking can unintentionally contribute to this process by formulating differently and emphasizing different aspects due to generational differences. Our research aims to use a framework we have developed to automatically generate a set of questions that meets the requirements described in the study based on the data collected and processed according to the parameters provided by the teacher using our program (WTCAi), reducing measurement errors caused by generational gaps, thus increasing the efficiency of pedagogical evaluation processes. The role of adaptive learning systems is continuously increasing in education, leading to more research and development for their application.

This research holds numerous possibilities, as the more extensive the data set available, the more accurate research results we can obtain, and we will be able to draw further conclusions about other pedagogical process properties.

The WTCAi system can contribute to the pedagogical evaluation of educational institutions by providing data and insights that can inform the assessment process. Here are some ways in which the system can support this evaluation:

Data collection and analysis: The WTCAi system can collect a wide range of data on various aspects of the educational institution, such as student performance, teacher effectiveness, curriculum coverage, and engagement levels. This comprehensive data can be analyzed to provide a holistic view of the institution's pedagogical practices.

Feedback and surveys: The system can facilitate the collection of feedback from students, parents, and teachers through surveys or online platforms. This feedback can provide valuable insights into the teaching and learning experiences within the institution, helping identify areas of improvement.

Student performance tracking: The WTCAi system can integrate with existing student performance evaluation systems and provide real-time updates on

individual student progress. This information can help assess the effectiveness of the institution's teaching methods and identify students who require additional support.

Customized reports and dashboards: The system can generate customized reports and dashboards that consolidate various evaluation metrics into a visually appealing format. These reports can provide a comprehensive overview of the institution's pedagogical strengths and weaknesses, facilitating evidence-based decision-making.

In summary, the WTCAi system can be a valuable tool in supporting the pedagogical evaluation of educational institutions. By providing comprehensive data, facilitating feedback collection and enabling benchmarking and analysis, the system can provide valuable insights, for informed decision-making and continuous improvements.

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Opportunities of VR for Teaching History

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Abstract: The present study examines the opportunities of VR in the context of humanities and arts and – within their frameworks – in that, of history. Its novelty clearly lies in the fact that in this fields' cyberspace is not used either by public or by higher education. The inclusion of info-communication tools for history teaching, does not really follow the current trajectory of development. Educators usually work according to methods that have become the most common and familiar. This research clearly revealed that students, who regularly use the VR space, in a History course of teacher training, consider it experiential, user-friendly, simple, problem-oriented and thus, easier to visualize historical facts. The regular and widespread use of VR software could greatly and easily help to progress the historical curriculum space.

Keywords: VR; MaxWhere; history teaching; visualisation; Moodle

1 Introduction

In conformity with the objectives set out in its development strategy, in the years from 2016 to 2021, István Széchenyi University carried out a project aiming at the modernisation of education content. The project focused on proper development of the subjects meeting the requirements of digital, methodology and market needs. The project was granted assistance by the European Union (identification number: EFOP-3.4.3-16-2016-00016).

More than 210 subjects were updated or developed within the framework of Moodle e-learning, used by the university and in the 3D virtual education space, facilitating educational activities, as well as student co-operation more effectively. Lecturers from all the 9 university departments participated in the project, meaning that, the program had a great impact on the whole institutional education system.

As a result of the project developing lecturers had the chance to re-think or revise the content of their subjects, such as core curriculum or additional content, to revise the structure of the contents, as well as to modernise their methodological culture in a way, particularly characteristic of digital education [27]. As a consequence of the COVID-19 epidemic, such developments played a vital role for the successful realization of distance education last year.

The aim of our study is to first of all, define the concept of e-learning and then, to give a general picture – based on a previous research – of the usability of the electronic learning materials developed by Széchenyi István University in Moodle and on the MaxWhere 3D platform. Consequently, we will show herein, how effective the VR interface can be, when used for history teaching.

2 Preliminaries

E-learning contents of István Széchenyi University can be found in Moodle e-learning system from which educational contents can be visualized in MaxWhere 3D VR application with the help of links.

Though it does not have an unanimously accepted conceptual definition, the simplest way the concept of "e-learning" can be interpreted as a kind of education being realised through the application of digital solutions appearing on the computer, the Internet as well as on a wide range of infocommunication technologies, which support learning and the improvement of learning performance [4, 9, 16, 26].

Various advantages can be gained from the development of e-learning programmes, such as: [2, 3, 16, 17]

- Bridging geographical distances and fighting obstacles or hurdles resulting from locality
- Offering the possibility of individual learning paths, e.g. as a kind of support of the advancement of students' different individual learning rhythms
- Ensuring the development of lecturers' digital skills and abilities
- Improving the quality and efficacy of education through the latest educational methods

2.1 The Role Moodle Plays in Content Development

Moodle containing developed curricula, is an e-learning system of open source code, free of charge, in which, apart from following up the activity and progress of those participating in the education itself, it is also possible to compile, construct and store course content (curricula).

Created electronic learning environment means one where tools of both electronic information technology and communication technology play a decisive role in establishing the conditionalities of teaching and learning [4-6] and one that can have virtual dimensions as well [28].

2.2 Virtual Spaces and Education

Though there have been several attempts to give an exact definition to VR, no single definition has successfully been set out yet [21]. Hungarian Ollé [14] tries to interpret virtual environment as a 3D, artificial space, non-existent in reality, where both us and others can coexist in a 3D form, space and time whilst seeing this all the same from their own points of view.

Lopreiato finds that VR environment means a wide range of computer applications generally associated with extremely visual, fascinating 3D characteristics that enable participants to look around and navigate in an apparently real or physical world [20-22].

According to the US Ministry of Defence: VR means the usage of computing to create an interactive 3D world in which spatial presence is sensed by objects as well as both virtual environment and virtual world are synonyms for virtual reality [21, 23].

A considerable characteristics of such spaces is that they can be connected through computer based, cooperative and technical instruments [14, 18]. Therefore, virtual reality is a simulated environment intending to describe and simulate the processes of the real world, with the help of computer models. It is partly a common, shared space, where various users can be present at the same time.

As a consequence, events, activities do happen in real time, providing for direct communication and cooperative work through internet-based applications.

Users can produce, create or develop contents and construct common documents [10, 12, 13].

A great advantage of VR environment is that it is accessible from space and time, it is cost-effective and easy to use. 3D VR student environment helps the processes of obtaining, filtering, admitting, processing and using information through parallel and arranged presentation or the visualisation of information [7, 10, 11].

2.3 Maxwhere 3D VR Platform

When entering deliberately designed and equipped virtual education spaces during the activity (i.e. teaching) in 3D virtual spaces, those interested (teachers/lecturers and students) can gather information essential for studying. Equipped spaces not only make activities more spectacular in the digital environment, but makes

information gathering faster and cooperative activities easier to realise, too [8, 9, 15, 19].

Nowadays Hungarian developments can also be found among the available virtual spaces, such as MaxWhere, the development of which is being carried out with the help of the University. MaxWhere can be used in the fields of education, project management, presentations as well as in interactive 3D presentations, too. In addition to the Moodle system, Széchenyi University focuses on the MaxWhere platform, when developing course contents (curricula). MaxWhere is a software that is easy to manage and free to access, which can be found at www.maxwhere.com.

Using MaxWhere may speed up workflows, therefore its application in the field of education is of particular importance. Well equipped space a priori offers a learning path considered effective beside which only contents previously filtered by a formulator, meaning that users can work using authentic sources. It does make the usage of various (teaching) applications in VR space possible.

So-called smartboards can be found MaxWhere spaces where digital materials to be visualised or presented can be loaded to. Each smartboard is considered to be an individual or separate "monitor" or "screen" where – apart from various file types (texts, images, videos, voice, etc.) – websites and applications can also be presented and used. Today MaxWhere grants a cloud computing (CC) service as well, therefore it is needless to send files because everything becomes immediately available when entering the given VR space. Moving in space takes place with the help of a mouse, and the scrollers and keyboards help precise movements, in which suggested routes can be set to reach course contents.

2.4 Comparison of Classical, e-learning and MaxWhere VR-based Learning Frameworks [8]

In the following, we begin by outlining the 3 most common techniques used for sharing digital workflows. We then compare those techniques based on the conceptual framework outlined in earlier sections. 1. Classical – TXT based message This technique consists of sending digital elements and digital content to a group of recipients as attachments to a text-based message, or as web links inside a textbased message (e.g. sent via e-mail or any kind of messenger application):

1) **Classical – TXT based message:** This technique consists of sending digital elements and digital content to a group of recipients as attachments to a text-based message, or as web links inside a textbased message (e.g. sent via e-mail or any kind of messenger application). Because of the text-based medium it uses, the classical technique can be regarded as an example of Digital Comprehension of the 1st order. In the case of digital workflows conveyed through text, the associated digital elements cannot be integrated into the text (although links to web-based content can).

2) **Online interfaces such as Moodle:** This technique consists of helping users access and / or download digital elements and digital content through an online web-based interface. In the simplest of cases, the approach of using online interfaces can be equivalent to the classical approach (with the added quality of being web-based), such that the task to be carried out is described using text, and the required digital elements are listed in some order at the end of the text. At the same time, an important advantage of online interfaces is that links embedded into the text can be used to share not only digital elements that have a web-based url, but more generally any kind of digital format (EDE). Thus, the digital elements can be ordered inside the text as required by the digital workflow, and sequential DGs can be conveyed without a problem, as long as the digital elements are ordered and users are able to move between them using a scrolling operation or a specific combination of keys (e.g. page up and page dn). Online interfaces are not amenable to the presentation of digital elements in a 2D process diagram. Thus, even if a digital workflow is presented through an image or a diagram, this solution can be regarded as only partial in view of the requirements of 2nd order DCs.
3) **The MaxWhere Operating System:** From an IT perspective, the MaxWhere OS contains no digital elements. Instead, it gives users access to a single (pack or bundle) file, which can be loaded and which contains references to all of the digital elements that are in turn loaded recursively. All digital content and elements thereof are displayed in thematic groups in 3D. Digital elements are displayed in smartboards, or opened using browser technology integrated into smartboards, hence the representation of the elements is of type EDE. In contrast, to text-based descriptions, the entire process underlying the workflow is in this case represented spatially, through digital elements that are laid out and opened in space.

2.5 Experimental Evaluation of User Effectiveness [8]

2.5.1 Digital Workflow

The key to solving the digital workflow effectively was the appropriate organization of the digital elements. Thus, users had to make sure that they could answer the questions on the first three tests based on the information contained in the PowerPoint file, the PDF file and the video file, respectively; and that they could answer the questions on the final test based on all 4 webpages provided to them in the context of that test. Since the task could be carried out by considering the digital elements in sequential order, the DW can be regarded as being of the 1st order. Naturally, the fact that in specific cases users could decide to go back to the previous digital elements for clarification does not mean that they are required to do so, and does not increase the order of the DW.

2.5.2 Sharing of the Digital Workflow

Classic: one group of users received the DW based on the classical approach, through e-mail. The body of the email contained a textual description of the workflow, and the digital elements required for the workflow were attached to the e-mail. Finally, the webpages and tests were included as links at the end of the body of the email. The naming of the attachments and links were chosen to reflect the identity of the digital elements well. B. Lampert et al., MaxWhere VR-Learning Improves Effectiveness over Classical Tools of e-learning – 138 –

Online Interface: A second group of users received the DW on through the Moodle platform. Similar to the classic approach, the description of the workflow was text-based in this case as well. However, a simple form of digital guidance was also available to users in this case, given that each step within the description of the workflow included an embedded reference to the digital elements required for that step. As a result, users were able to perform the workflow step by step, instead of first having to obtain a holistic overview of the workflow. In effect, the users' ability to scroll through the steps guaranteed a DG of type S in this case.

MaxWhere: Regardless of whether this group of users received the workflow on an online surface or through the classical approach, they could import the digital elements into MaxWhere, which then provided a spatial arrangement of EDEs in smartboards. In the case of the PowerPoint file, each slide was added to a separate smartboard. The tests were loaded in smartboards that were closest to the digital elements related to them. The MaxWhere Operating System also had built-in functionalities for S and R type DG, which could be made use of by the test subjects.

2.5.3 Results of the Experiment [8]

The number of students tested using the classical e-mail with attached content and with linked content, online platform and MaxWhere-based approach were 115, 77, 97 and 90 respectively.

Figures 1, 2 and 3 show the results of the test. The horizontal axes represent the time required to complete the test. The vertical axes represent the percentage of users corresponding to the given number of minutes.

The average and standard deviation of the time required to complete the workflow in each of the cases were:

E-mail with attachment:	average: 6:42	standard deviation: 3:02
E-mail w/ Google Drive links:	average: 5:54	standard deviation: 1:39
Moodle:	average: 6:42	standard deviation: 3:03
MaxWhere	average: 3:11	standard deviation: 0:46

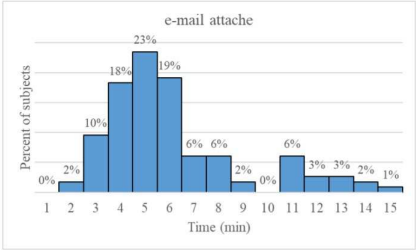

Figure 1
Test in which files were sent via e-mail attachment

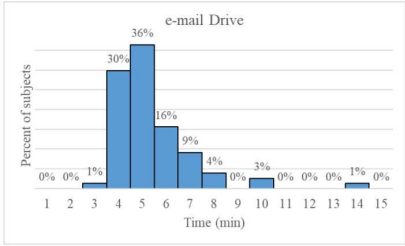

Figure 2
Test in which digital content was sent through Google Drive links via e-mail

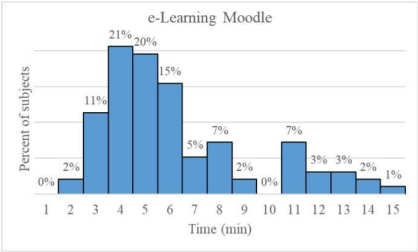

Figure 3
Test in which the digital workflow and digital content was shared through the Moodle e-learning framework

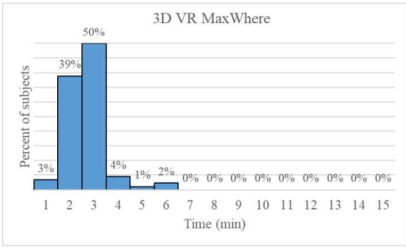

Figure 4
Test in which the digital workflow and digital content was shared through the MaxWhere 3D environment

The results: the MaxWhere VR environment could complete digital workflows in considerably less time (i.e., 50% faster) than using the more traditional (e-mail based and content management system based) approaches. It is also remarkable that the standard deviations of completion times are considerably smaller in the case where the MaxWhere-based approach was used. Although the reasons behind this observation may need to be clarified through further investigations, it nevertheless points to the conclusion that the whole process of comprehension is rendered clearer than usual in 3D environments capable of representing 4th order digital workflows with automatic guiding, as pointed out in the paper [8].

2.6 Methodological Issues of Teaching History

Educational methods are the set of procedures, activities, organizational methods and techniques that are consciously planned and applied, with the help of which the set educational goal is achieved. The term is derived from the Greek/Latin word ‘methodus’, which means the path to the goal. The main features of the teaching methods are that they:

- Are repeated regularly

- Allow Teachers, as the controllers of teaching/learning, to consciously plan and apply
- Let Learners, spontaneously and/or consciously learn and apply them as subjects, in the learning process
- Are goals (content and aid dependent)
- Interact with each other, to form combinations of methods

The specific methods and teaching strategies of the individual pedagogies, such as history pedagogy, are influenced by the cognitive techniques and processes which are characteristic of the subject. The conscious purposeful choice of methods is influenced above all by the aims of teaching, the peculiarities and content of historical cognition.

Those who teach history undertake to assist their students professionally in the process of cognition of history. They direct students' attention to the past and help them learn about, understand, reconstruct, and interpret the past. The history teacher is called upon to play an active role in shaping the so-called 'narrative competence' of the students. In the course of learning history, students learn facts, data, knowledge and interrelation that form the basis of their general historical education. However, their acquired historical knowledge and knowledge of specific data will only become relevant and useful knowledge for themselves and society if they are able to flexibly adapt the constructions, schemes and concepts offered by historical science to their understanding of the past and the present.

This requires not only historical knowledge, but also an intellectual ability (critical analysis, readiness to debate, adaptive, problem-solving thinking, etc.) to handle and process historical problems, use the acquired knowledge and apply it to the present. Thus, learning history means not only – and not primarily – learning historical knowledge. Historical learning means, above all, historical thinking, the ability of the learner to think in the three dimensions of the past-present-future, to know and apply the most important components of historical research procedures according to their age characteristics and level of development.

The historical literacy material learned in school can no longer be a closed, extremely canonized set of knowledge. If we start from the fact that life prospects of today's students can be predicted for at least 50–60 years after completing their schooling, then orientation knowledge for the future must be open, expandable, and self-improving. This condition is only guaranteed if there is a conscious and well-practiced methodological competence. Future generations must therefore have historical knowledge based on a cognitive content base that is adapted to the receptivity of students, both in terms of science and history, and of methodological competence that contributes to the development of their own historical consciousness. The historical knowledge and the methodological knowledge intended for their processing are in close interaction, it can also be said that the specific way of thinking of the subject of history is verified in and through the methods.

The main goal of teaching history is to develop a conscious, enlightened, reflected view of history in students, which enables them to understand the possibilities and limitations of people and human communities in the past, the motives of their actions, referring the historical problems to the present and orient them in the future [24]. The question is… What modern "info-communication" tools and methodological innovations, can be used to achieve it?

2.7 Challenges of History Teaching in the 21st Century

There have been spectacular changes in classroom practice since 2005. The diversification of tools, the regular, daily routine use of textbooks and task collections, the conscious and professional use of different forms of group organization, the frequent activities of students, the reflective application of knowledge acquisition procedures, and the monitoring of student performance can all be considered encouraging signs. However, learner-centred, cooperative classroom management strategies, projects, controversial and multi-perspective approaches are still lacking or they are present to an insignificant extent, and what is more, political and event history still prevails. In addition, the use of info-communication tools and aids also leaves something more to be desired.

This is also supported by a study based on transcripts of 48 lessons (6 schools, including 4th and 8th grade grammar schools, different age groups from 5 to 12 grades) and the observations of teacher candidates. On the lessons, which the study is based on, the teacher candidates observed the use of the following tools and media (in order of their frequency): blackboard, map (wall map and student atlas), teacher worksheet, overhead projector, textbook, workbook, instructional and art film, projector. As for the board, it can be said that it is almost exclusively a tool for creating a teacher's outline, but it is strange that it is also used only in a fraction of the lessons. The same can be said for almost any device. All history teachers used some kind of tool (on average one or two per lesson), however, this affects a relatively narrow range of tools and we found a partial or complete lack of important tools. (For example, the map did not appear in one of the history lessons examined, where the teacher explained ancient folk movements.) In none of the lessons examined were computers, Internet, interactive tools or student presentation tools used.

Worksheets prepared by teachers have once more become a popular tool, used partly for practice but mostly for measurement and evaluation. In almost all cases, the workbooks were used to draw the students' attention: during the oral presentation, the students in the class were to solve exercises in the workbook individually and then checked the solution together. Thus, the solution of the exercises is extremely formalized, it is not built in the content structure of the lesson almost anywhere, and it does not principally serve the purposes of development, but a disciplinary tool and a tool for preparing for the exam.

Regarding the forms of group organization, the frontal class, the teacher's presentation (presentation, explanation) and the method of expressing the question are still popular, but teachers no longer use individual problem solving and plenary discussion (although based on the minutes, we can conclude that the conversation involves teacher questions and student responses) as well as pair and group work. (In 3 and 3 history lessons of the 50 examined). There was also individual collecting activity, drama pedagogical and role-playing tasks.

In terms of content, the guideline for most of the lessons has remained event-related topics. Problems were raised in two or three lessons, and contemporary problems were discussed in connection with historical phenomena (e.g., a discussion of ancient and contemporary slavery). On some occasions, students were also given the opportunity to ask questions. Students' knowledge was tested in a significant part of the examined classes. The most important forms of examination are oral response and written dissertation, which are usually followed by oral as well as written (graded) assessment. We did not find any examples of student self-assessment or portfolio building.

When evaluating the practice of teaching history, although we see massive survival of previous frontal methods, we need to see more frequent and conscious use of other methods considered desirable in content regulators (including tool use, learning organization procedures, and various forms of teacher-student interactions), the organization and awareness of the chosen methods and contents.

It is worth briefly considering the aspects and attitudes of the protocol writers. The choice of observation criteria selected by the teacher colleagues or students majoring in teaching (teacher questions, disciplinary methods, the logic of the teacher's explanation, the observation of the use of tools) is very specific. These aspects of observation allow us to conclude that although university students majoring in history have become acquainted with many modern methods and tools during their university history teaching studies, their approach to modern methods beside their curiosity about them is largely based on their own grammar school experiences and unconditional trust in a conservative methodological culture (understand: teacher and knowledge-centred, descriptive-explanatory, static), hence it can be characterized by some distrustful attitude towards form-breaking, learner- and problem-oriented methods.

Thus, it can be stated that the methodological and content renewal of history teaching has started on the basis of the above mentioned experiences in the curriculum documentations, the output regulation of the graduation exam and the teaching practice of educating teachers, but the achieved results can still be considered partial [25].

However, as the above results show, the inclusion of info-communication tools in history teaching does not really follow the current trajectory of development. Educators usually work according to the methods that have become the most common and familiar. And this can clearly pave the way for VR in teaching history,

which can open up a whole new perspective in it, making history curriculum lively and easy to handle.

3 The Thesis

Humanities and Arts is the least affected area of VR content development. It is a method used more and more frequently in technical, information and, among others, social sciences as a consequence of which it can open new perspectives in teaching history as well. At the Apáczai Csere János Faculty of Humanities, Education and Social Sciences the chosen literacy field of Man and Society presented a great opportunity to adapt History course transmitting the core curriculum to MaxWhere as well as to develop its curricula. This course is generally completed in this chosen literacy field by 5 to 10 students per year. Two lectures and two seminars are included in the course on a weekly basis meaning considerable amount of workshops apart from teacher lectures. According to our hypothesis, those who have already encountered it regularly use the VR curriculum belonging to the already completed History course due to its versatility, simplicity, spectacle and easier visualization of historical events.

4 Method

The aim of our empirical research is to examine how easy and accessible the one-semester material of the History course can be found in the Moodle system and through this access point on the MaxWhere 3D platform. For the research, we created an online questionnaire using Google Form. The questionnaire contained 19 items. Of the questions, 6 were closed questions, 8 open-ended questions and one assessment scale question. The respondents were participants of the course, a total of 6 people. They were all 3rd grade students with an average age of 21.5 years. The questionnaire was completed at the last seminar of the course.

5 Discussion

Be it either public or higher education, history in Hungary has been taught mainly through traditional methods in 2023 – within this, frontal classwork has been the most frequent form of teaching. Though modern electronic learning materials are already available for students both at primary and secondary schools, making visualisation of history materials much better and easier to understand with the help of smart tablets and other infocommunication tools available at the institutions, such materials are still rarely used by the teachers – reasons for this vary.

Teaching history is a rather complex process that has to present not only the facts, concepts and correlations of greater importance, but it also has to affect students' complete personalities, too, while "human shaping", emotional education and that of will also form part of it. Teaching history rests on the three fundamental methodology pillars of i) story, ii) history and iii) student activity. These three pillars help us reach the essence of history. Students get to know the elements building up history through stories told. The story itself is the phenomenon, history is the essence which requires the analysis of both learning materials and sources, and it also trains us to think and make others think [1].

Based upon the above we can say that teaching history, independent of its level, can indeed be adapted to VR spaces by leaving the old methodology. Integration of e-learning materials becoming increasingly available in MaxWhere imply a new perspective on fulfilling its aims and mission.

Another reason why piloting the curriculum or learning material of the course transmitting the core curriculum was so important in the case of the chosen literacy field of Man and Society was to provide students with ideas and innovative tools for the methodology of teaching history.

One of the most important aspects during the preparation of the 14 module-curriculum was familiarising with the software itself. One of the aims for students was to improve and increase management and usage of the programme, unknown until then. The other aim was to make their historical approach change as well as sense of both space and time develop and to make them see historical correlations clearly. (Figure 5)

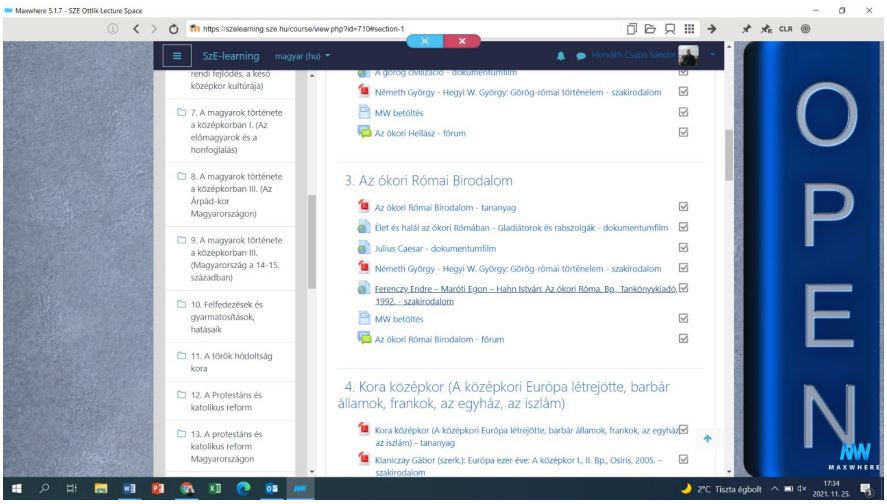

Figure 5

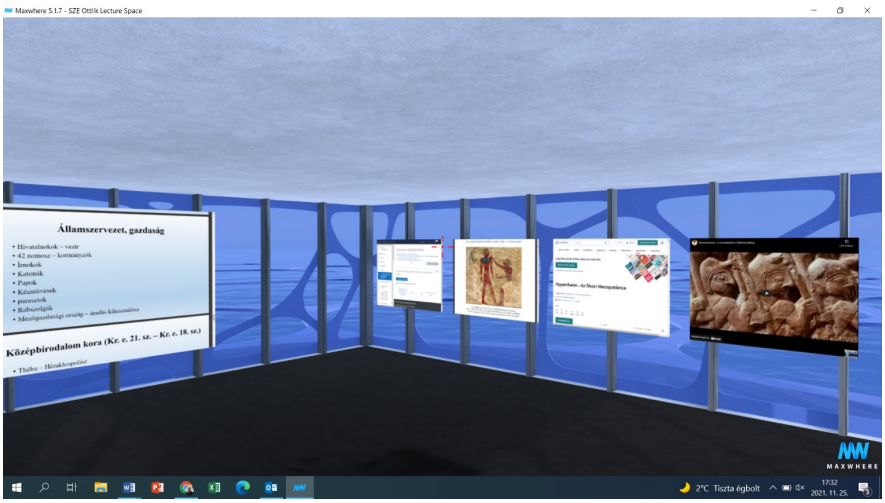

Figure 6

As far as curriculum is concerned it was of great relevance that students be able to process the given amount of knowledge in admissible, well visualised way, even individually (alone), with the help of the least explanation or guide available.

From the ancient Eastern culture to modern times, each unit contains a draft elaborated by the lecturer, which are updated versions of former PPTs.

The main idea here, too, was that the slides gave a kind of sketch and focus on qualitative history teaching in the most simple way possible and emphasizing nodes/junctions – i.e. not focusing on years and dates (this way avoiding one of the mistakes and difficulties of old times' history teaching), but starting from stories and concentrating on connections by mounting them on a chronological thread. This inevitably requires thorough visualisation of the topic, and introduction/presentation of various images and both material and written sources.

The next idea was to make indispensable material and written sources immediately available (apart from the PDF drafts appearing in VR space) for students in the given space (mostly in Ottlik Lecture Space) on further boards. (Figure 6)

In the previous one even the Giza pyramids can be examined with the help of a documentary film available on the Internet looking for its then contemporary importance and connections resting in the social arrangements as well as the size and construction of the tombs. (Figure 7)

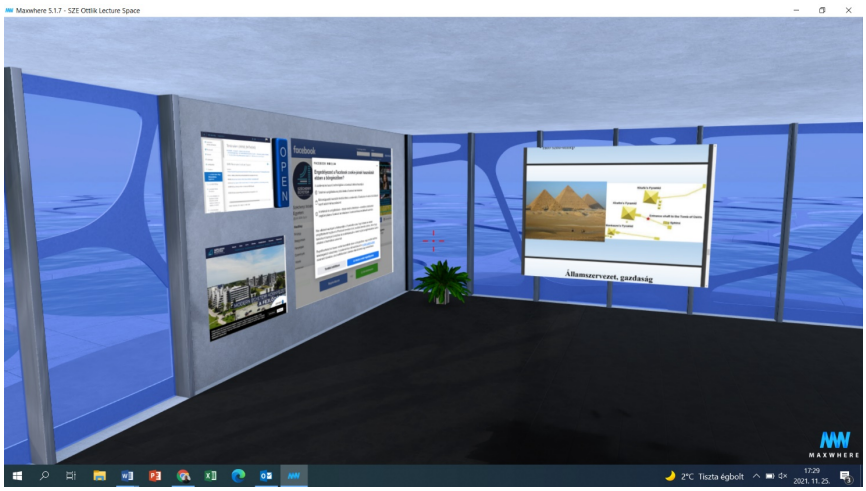

Figure 7

Just here, in another "window" hieroglyph texts can be presented through a translation programme with the help of which students have the possibility to decode the given texts and, as part of the following exercise, they will be able to transcribe Hungarian expressions to hieroglyph letters. Working in a common space makes everyone's creativity as well as the extent to which students understood the given task can easily be checked and verified.

These kinds of exercises perfectly fit workshops where students can do former, usually dry and boring source analysis kind of together in the virtual space. Besides, scientific literature relevant in terms of the lecture and available on the Internet can also be presented, making students' work easier. A kind of "mini library" of indispensable and compulsory special or scientific literature can also be created in the VR space.

As far as curriculum/learning materials are concerned, their position in the historical space is also of great importance. It requires the common study and analysis of maps presenting the given age or era guided by lecturers.

VR space make the visualisation of numerous maps possible, the best ones of which are picked by the lecturer. It is also necessary to use blank maps, too, in order to develop students' topographic knowledge and orientation. In this respect, the usage of the common educational space is considered as novelty, because students can do their tasks in a digital way – instead of paper-based materials – the correction and common control of which – even at home – is also made much easier.

This way the two competences most difficult to develop, that is the learning or mastery and extension of the senses of historical space and time, can be broadened with a kind of help never seen before through VR. Finally, students can present and visualise the topics chosen through a board – this way, making them understandable

for everyone while the given learning material becomes easily verifiable and evaluable for lecturers. (Figure 8)

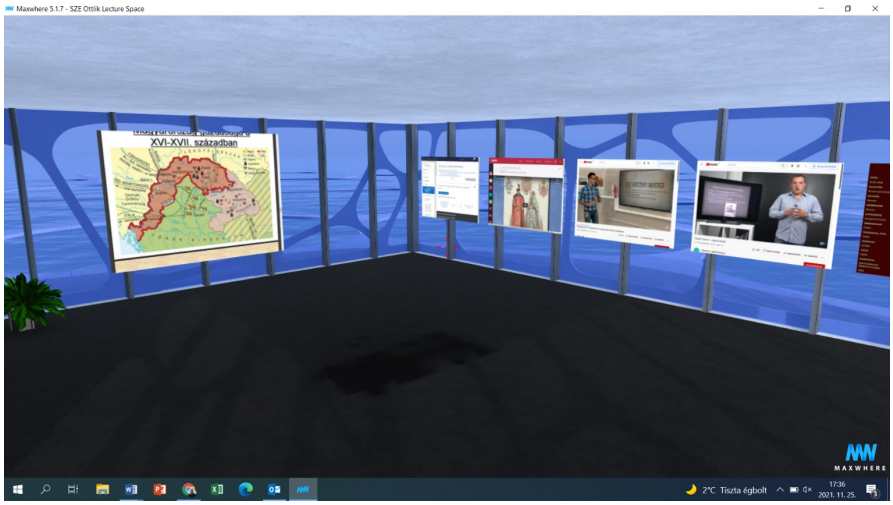

Figure 8

The new methodology has, without a doubt, increased students' motivation in getting to know history. During education in the virtual space it was also a great advantage that, especially in times of the pandemic, it was possible to join the courses online in their real time and that units uploaded are also available.

The next aspect was simplicity. Following a little practice everyone is able to manage and use MaxWhere in a self-confident way, perfectly orientate in it, to quickly find everything or can even develop, complete and upload their tasks.

As a consequence, the usage of the software is highly recommended in the case of different courses of history, too. It can be extremely useful when giving lessons of history didactics and, later on, it could also be applied either in teaching history at public or secondary schools.

The only difficulty it has is its high hardware need on behalf of the students who may not always be able to guarantee it from home either.

5.1 Student Evaluation of the Moodle e-learning System

After evaluating the questionnaires, the following results were obtained:

A significant number of students (83%) have been using the Moodle e-learning framework for 1-3 years in various courses. Based on their answers to the open-ended question, they are generally satisfied with Moodle. Their justification is that they can access a lot of learning materials on it, they can easily navigate the

interface, they can practice for tests related to exams. One of them also highlighted that the interface is constantly evolving.

What they are particularly satisfied with is that they can find all the learning materials in one place, complete with a bibliography. The interface is simple, clean, easy to understand. However, two students complained that the interface was not spectacular, while two students emphasized the slowness of opening and downloading materials.

The development proposals are also related to this. They would make the interface more colorful and spectacular (2 people), simplify and speed up the opening of uploaded files (2 people). A student would be happy if it could be used offline.

5.2 MaxWhere 3D VR Student Rating

67% of students (4 people) first encountered the MaxWhere 3D VR interface in a course, 1 person used it in the previous semester, and one person declared that they have been using it for 1-3 years.

The general opinion about the 3D VR interface is that the interface is much more colorful and spectacular than Moodle. Meanwhile, it is also relatively easy to use. There were (1 person) who perceived it faster than Moodle. Two students emphasized that learning materials (text and image files) load quickly into the space, and you don't have to open multiple windows at once like in a traditional browser, because everything is in one space. "We can see several things at once."

Three people emphasize easier learning in 3D space, e.g. "In a 3D environment, a person can connect the given material to space." or "You can build a learning line." This is especially important because the student realized that the learning materials in the space are not random, but the instructor consciously placed them behind each other (learning path).

Compared to Moodle, they can open materials in space with fewer clicks.

It is also considered an advantage of the 3D VR interface that communication with peers and instructors can be realized within the space, there is no need to open other surfaces or use a separate smartphone. "It is possible to communicate via video call without leaving the space."

Navigating in space can be highlighted as a difficulty from the research, but this was also evaluated by the student as having to be practiced at the beginning and easy afterwards. So, you have to get used to the new system, but one student suggested that there should be a separate course just to learn how to use MaxWhere. After that, they can easily use it in the other courses. Another development proposal was the "optimization of software", by which the student meant to be able to run stably even on a machine with weaker hardware.

Already while using it, students found it faster to open materials in MaxWhere than in Moodle. We checked this intuition in the next task, where they had to open the same curriculum in Moodle and MaxWhere while counting how many clicks they managed to solve.

In the case of Moodle, everyone (n=6) needed 12 clicks, while in MaxWhere 4 people (67%) managed to open the curriculum with 3 clicks and 2 people (33%) with 4 clicks. This means that 67% of students needed a third as many clicks to open the curriculum.

In the final stage of the questionnaire, students had to evaluate 5 statements, where 1 reported "strongly disagree" and 5 reported "fully agree." (Figure 9.)

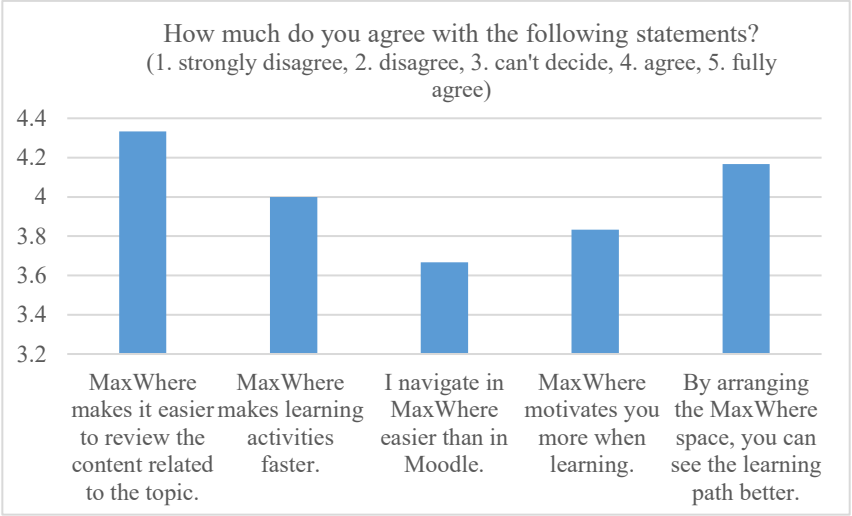

Figure 9
What students think about MaxWhere. (n=6)

What students agree on more significantly is that:

- "MaxWhere makes it easier to review the content related to the topic." Avg. 4.33 (n=6).
- By arranging the MAxWhere space, you can see the learning path better. Avg. 4.167 (n=6)
- MaxWhere makes learning activities faster. Avg.: 4 (n=6)

And what they no longer clearly agree on is that:

- I navigate in MaxWhere easier than in Moodle Avg. 3.67 (n=6)
- MaxWhere motivates you more when learning Avg. 3.83 (n=6)

Conclusions

All in all, it can be stated that VR does provide numerous and unique possibilities for Arts and Humanities and, within this field, for teaching history. Though this kind of curriculum development has only been realised in the case of history courses, the advantages of teaching and learning in VR can already be noticed. It made each others' availability and the accessibility of learning materials much easier for both lecturers and students – especially during the pandemic – as well as it resulted in a new approach to the pedagogy of history as a subject. At the same time, they pointed out the shortcomings of today's history didactics, which could be flexibly healed by them. Resulting in an experiential, problem-oriented, illustrative, stimulating for self-teaching and multi-perspective history teaching. However, a more thorough examination is needed, in order to be able to make further statements and conclusions.

The empirical research revealed that most of the students only encountered MaxWhere's 3D interface for the first time in the History course. However, after that, those who also use Moddle regularly also worked with VR. The reason for this is mostly its simplicity, clarity, spectacle, richness of content, easier communication with the instructor and easier visualization of historical events, so our hypothesis was confirmed, and the students even presented other advantages. The research also confirmed that the same content can be accessed with a lower click rate compared to Moodle. The difficulty was navigating the software, which would be greatly facilitated by wider use. The optimization of the program was indicated as a development proposal. Therefore, it can be concluded that both software programs can greatly help the processing of the content of the History course, and the regular use of MaxWhere can open up new horizons for students and motivate them better.

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Security Implications of Computer Botnets

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Abstract: With the explosive growth in popularity of computer networks, so-called botnets appeared. These contain many infected smart devices that the owner can control remotely. The members of the botnet can carry out – usually illegal – tasks in a coordinated manner, which can cause significant damage to the targeted infrastructure. In addition to spam campaigns, Distributed Denial of Service attacks and other usual procedures, actions aimed at influencing public opinion are becoming increasingly popular, which can cause damage beyond IT environments. Popular social platforms have become targets for propaganda and other social engineering campaigns executed with the help of botnets. Another threat will be the growing use of artificial intelligence by attackers, which can significantly increase the effectiveness of the offensive activity of a botnet. In this article, I have tried to provide a comprehensive overview of the current and near-future risks to society posed by botnets and increasingly widespread artificial intelligence.

Keywords: malware; botnet; AI; LLM; DDoS; attacks; IT security

1 Introduction

With the help of computer networks, not only the classic, “traditional” computers can communicate with each other. By moving to the digital world, various electronic devices have “intelligent” control, so today, many smart technologies use such networks for communication purposes. Connecting devices with different capabilities and rather heterogeneous technological backgrounds also carries serious risks. Many modern devices contain a – sometimes unnecessary – computer inside. Every computer application, program or function library can contain errors, a natural part of complex IT systems. However, the interconnection of devices sometimes allows such programming flaws to be exploited remotely over a network. If the error is so serious that the attackers can install a malicious program code on the target device, they can gain control. This means they can download and execute applications to reach their desired goal. The popular name for such malicious program code installed on a victim computer is “malware”, a combination of “malicious software”.

These malicious programs run on the attacked device and thus have access to its entire set of resources (e.g. processor, memory, storage, network data transfer capacity). Since they can communicate with each other via computer networks – Local Area Networks or the global internet – it is, therefore, possible to make a distributed system out of them, that is, to make them take coordinated action with the help of central control. Such "hacked" devices are called zombies, robots, or bots for short; the network formed from them is usually called "botnet". The most important elements of botnets are:

- C2 (command & control) server. However, there are peer-to-peer solutions where any botnet member can act as a server.
- "Herder" which is the controller of the botnet, who assigns tasks to members. Also, known as "botmaster".
- Members who form the botnet. Usually, infected computers or other smart devices.

This article is based on personal experiences and extensive research using information from industrial sources.

1.1 Usages of Botnets

The size of botnets can vary greatly, depending on how successful the malware's infection activity was. Most malware tries to replicate itself, but the malware detection systems can identify and destroy the threat and the established botnet after some time. The strength of a botnet mainly lies in its size: the more devices it contains, the greater its computing capacity and the greater the network data traffic it can generate. Due to its distributed nature, a botnet can be used for tasks that can be effectively parallelized and divided into independent subtasks. This means the botnet members can be assigned to a partial task, which they can perform independently, and the result can be forwarded to a specific location. Some of the more popular application areas:

1.1.1 Password Cracking

Nowadays, the so-called "cloud" services have become significant. Most of these systems use authentication, some form of user registration. The popular method uses username-password pairs to identify and authenticate users, creating large databases of registered users' data. Such databases, which contain at least email addresses and passwords, are popular targets for attackers. If the protection of a web system is inadequate, stored user data can be leaked, usually in some form of database format. Fortunately, systems where the passwords are stored in an unencrypted – plain text – format is now rare. Usually, one-way encryption is used, and no simple method is available for decrypting these stored passwords. In doing so, the password provided by the user during registration is processed by a

so-called “hash algorithm”, which produces a certain number of bits – usually a fixed length of data. The algorithm is specifically designed to scramble original bits that the original data cannot be restored by using purely the result. During the hash process, specific actions are performed that cannot be reversed because bit losses and overwrites occur. When logging in, the same password entered by the user is run through the same algorithm, so the same result should be obtained. If the generated bit sequence differs from the value created during registration, the wrong password has been entered, so the user's authenticity cannot be established. Decrypting passwords stored with this method – as the algorithm cannot be reversed – cannot be solved algorithmically. Brute force probing is the only possible solution. During this, different passwords must be generated – randomly or based on a dictionary – and run through the same algorithm used by the target system, and then check whether the obtained result can be found in the stored list. The correct password – or an equivalent sequence of characters – is found if so. Otherwise, the attempt must be continued.

This task can be perfectly parallelized; the list of possible passwords can be distributed among the botnet members so that the password cracking time can be drastically reduced.

These decrypted passwords can be used for hijacking accounts in different web applications, as, unfortunately, many people use the same password on different sites. On the black market, many password lists are available gathered from different data breaches.

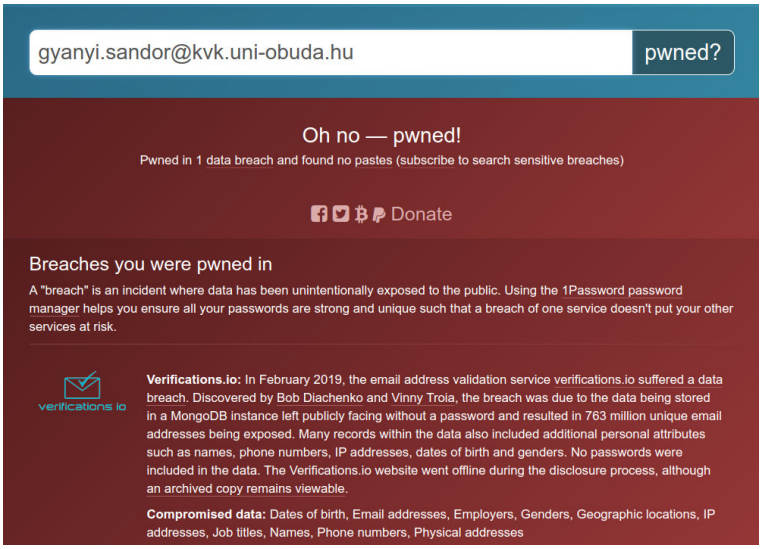

Figure 1
Data breach check on https://haveibeenpwned.com/

1.1.2 Spam Email Sending

Everyone who uses email has come across unsolicited mail. The type of these messages can be different:

- Marketing offers. The subject of these messages can be very diverse. They typically advertise products that cannot be advertised through traditional marketing channels (like medications, fake products).
- Malware. Some malware tries to infect others by sending emails to email addresses found in the address book of victim computer.
- Phishing. They try to take advantage of the credulity of users, usually impersonating an existing, authentic service provider. They try to direct the target person to the attacker's website and obtain their login or personal data.

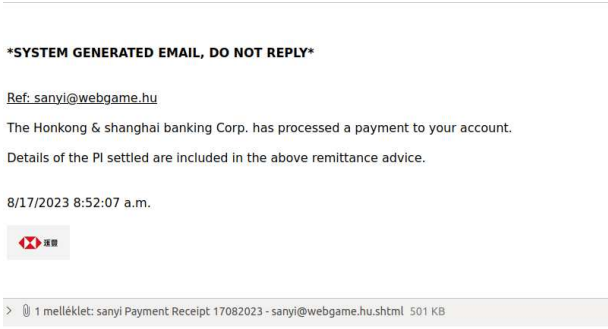

Figure 2
Phishing email

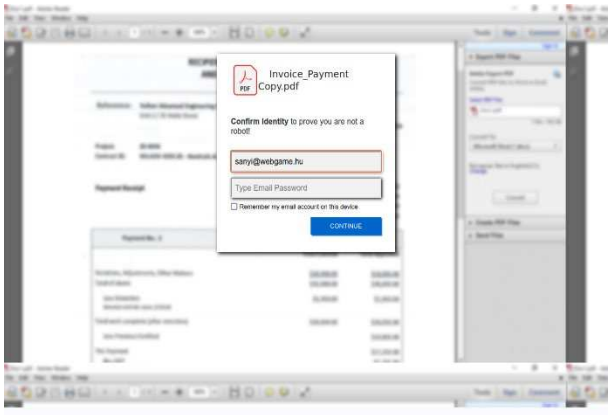

Figure 3
Phishing form

1.1.3 DoS and DDoS Attacks

In the classic data security threat triad – violation of Confidentiality, Integrity and Availability – the forced limitation of availability is a serious threat. Limiting availability is most easily achieved by causing overload in the targeted system. If the target is forced to perform too many tasks, the execution time can increase so much that it appears inoperable to users. Too many tasks mean the target lacks the resources to complete these requests in time. This way, an outage can be caused even if the target system is unknown to the attacker. Such attacks can be performed in several ways:

- By exploiting a known or newly discovered vulnerability of the target.
- By vastly overloading the communication channel used by the target, for example, by sending large amounts of unwanted data.
- By sending requests that make the target perform excessive tasks.

The usual name of these attacks is Denial of Service (DoS) or Distributed Denial of Service (DDoS) when the attacker uses a large number of hosts. A significant advantage of botnets is the ability to carry out DDoS attacks. Since they contain a large number of infected machines, the resources of these bots are adding up. It is very difficult to defend against them, as there is no well-defined profile for implementing defense. They are geographically dispersed, and many different networks could be involved, so network filtering based on the source address is impossible.

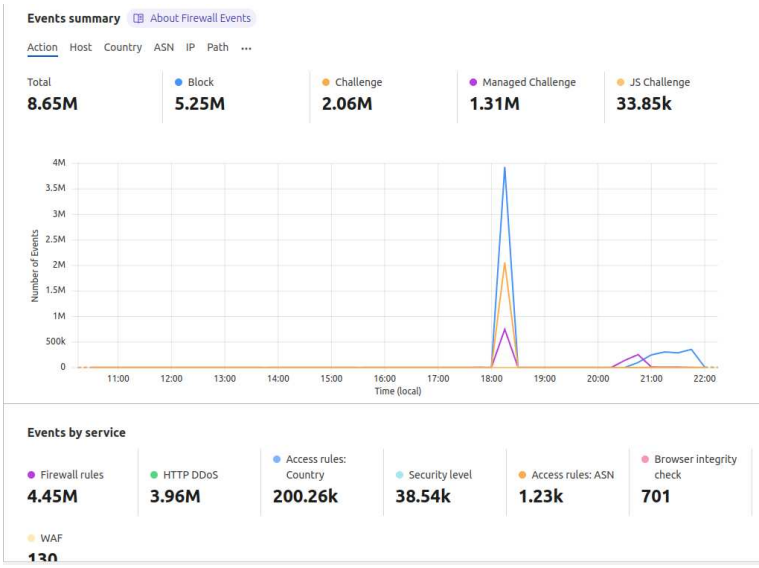

Figure 4
A DDoS attack timeline

As Figure 4 shows, the attacker caused an irrationally high request number in a very narrow time period. Most systems are scaled to the average, expected traffic. Depending on their size, botnets can carry out very large, so-called volumetric attacks, which often exceed the resources available to the average target. On February 11 and 12, 2023 – the weekend of the American Super Bowl – Cloudflare, a service provider specializing in protecting against DDoS attacks, prevented a record-breaking attack. The attacker botnet generated 71 million requests per second. [1]

1.1.4 Crypto Mining

The basic principle of cryptocurrencies is that they do not contain a central registry, but the authenticity checking is performed by endpoints operating in the system. During the verification of authenticity, it is necessary to make many mathematical operations, which require serious computing resources – primarily provided by the computer's central processing unit (CPU) or the Graphics Processing Unit (GPU) located on the video card. The computation also needs significant electrical power consumption, which could cost a lot of money for the device's owner. If a botnet – more precisely, members of the botnet – perform the crypto-mining tasks, then the necessary computing power becomes "free" to the owner of the botnet, and unsuspecting owners of the devices will pay the price. To put this issue into perspective, the "Clipminer" botnet owners earned at least $1.7 million from crypto mining. [2]

1.1.5 Influencing Social Media

The use of social media has become extremely popular; more and more people use it to get information from there, but it can cause serious problems. There are specific processes and legal regulations to ensure the credibility of traditional media – newspapers, television, radio or news websites. Still, in the case of social media, these regulations and processes work with very limited efficiency. The primary goal of these social platforms is not to check the authenticity of the information published by its users but to increase the activity (engagement), as this can maximize revenues. The more committed and active a user is, the more pageviews and more additional content – like comments and "likes" – will be generated, which can push other users to engage. The more user activity, the more ads can be displayed to them. Thus, more advertisement revenue goes to the platform.

A proven – although not too ethical – method for increasing user activity is determining interests of the user as thoroughly as possible and to display corresponding content fit for these. Some would say this behavior is plain espionage, but the platform terms of service clearly describe and clarify these data usage conditions. How could the platform identify what users are interested in it? The most widely used process for content selection is the examination of the

reactions to a given content: the more people react to it – comments, positive or negative rating, number of likes and so on – the more valuable the content seems to the machine algorithm which controlling the users' news feed. This means content that gets a lot of reactions will most likely be seen by many other users. Using a suitable, large enough botnet, the botmaster can increase the reach of targeted content – post, photo or video – when the botnet members react to it in sufficient numbers. Of course, the owners of social media platforms are also familiar with these practices and try to fight against them. One of the most serious social media competitors of traditional media is the platform called Twitter – many journalists and other reliable experts also publish on Twitter. Many people get information from there, though one of the main problems with Twitter is that it has a lot of "bots" that actively try to influence the reach of certain content. [3] In 2022, Elon Musk acquired Twitter – and since renamed it "X" – and softened the user validating methods. [4]

Another big issue of social media is the advertising model. The pivotal point of online advertising is the effectiveness of ads, and it can be significantly increased by appropriate targeting. Suppose someone is interested in a particular topic, such as searching for a washing machine on various websites. In that case, they are likely to respond more to a relevant ad than if it were only shown to random users. Because of the increased effectiveness, these properly targeted ads can be sold more expensively to advertisers. On the other hand, increased targeting requires data from user activities, interests and behavior which could be problematic from a data privacy point of view. Some platforms – like Facebook and Google Analytics – provide free services to third parties, but in return, they track the activities of their users and collect data from their online presence. [5]

Interest-based content positioning can be extremely dangerous for society. Public opinion could be manipulated efficiently if it is used to deliver a political message instead of advertising a commercial product or service. Social platforms usually have a direct connection interface – the API or Application Programming Interface – for larger business partners, usually advertisers. The main purpose of these interfaces is to provide useful targeting information to the partners, making them more profitable. Using this, the partner can select the group important to the advertiser businesses and display targeted content. One of the biggest such scandals erupted in 2018 after a whistleblower revealed that the British company Cambridge Analytica harvested data from 50 million Facebook users, and this data was used for profiling these users. [6] These profiles were used to influence the 2016 Trump campaign and probably the Brexit referendum. Using data mining procedures, they could produce lists from the retrieved data and target ads for these users based on their political views. Although the ethics of the procedure is questionable, according to the investigation, no violation of the law was committed, and the available tools were used. [7]

1.1.6 Spreading and Validating Propaganda

The World Wide Web contains much information and facts, and the total opposite claims can also be found. For the average reader, it is almost impossible to distinguish between the news and fake information, and sometimes alternative narratives are available for the same event. As the geopolitical situation in the world deteriorated, many armies started using psyops (Psychological Operations) to interfere with public opinion in "non-friendly" countries. Many propaganda organizations put publications on questionable authenticity and smaller websites, but their reach is very low and their effectiveness extremely poor. However, with a sufficiently large botnet and the involvement of the "influencer" users, it is possible to share and promote the content on social media, resulting in a drastic increase in the number of readers. As mentioned before, a broad readership also means more shares and likes, which means the content can reach many more readers indirectly. In addition, due to this indirect sharing mechanism, the credibility of the post will increase as more and more users share or use the false information. When the information from the untrustworthy original source reaches the appropriate level of credibility, the originator organization interested in spreading the propaganda begin to refer to it in different information channels.

The effect of spreading propaganda on public social media channels can be extremely dangerous. Between 2016 and 2017, the Myanmar military took advantage of the popularity of Facebook to conduct a targeted campaign against the local Muslim Rohingya minority, which resulted in genocide [8].

1.2 Internet of Things (IoT) Problems

As microelectronics develop, more computing power can fit smaller, cheaper devices. More computing power allows communication between these devices using computer networks, forming the so-called Internet of Things. The rise of IoT devices seems unstoppable. According to estimate, the number of "smart" devices connected to the Internet reached 14.3 billion at the end of 2022 and will reach 16.6 billion within a year.

These devices have relatively limited capacity, and their operating systems are very different. Many of them may contain security holes. If such a device is vulnerable, the entire network is at risk. As a result of, a successful attack, an IoT device can be a target, but it can also be a tool in DDoS or other attacks.

1.2.1 Mirai Botnet

The Mirai botnet consists of smart devices infected with malware running on ARC (Argonaut RISC Core) processors. These infected machines can be brought under central control and, therefore, can coordinate actions. In September 2016, the

authors of the malware launched a DDoS attack against the website of a well-known security expert, and a week later, they made the source code public. Opening the source code of malware can provide a way to modify the original code more easily, and detecting these modifications will be much more difficult.

A serious mistake allowed the Mirai to infect devices automatically. Most manufacturers use the same stripped-down Linux operating system for the ARC processor, which had a default username-password pair for the root (administrator in Linux) user. If the password has yet to be changed by the manufacturer or the owner, Mirai malware could log in remotely and infect the system.

Infected devices can be baby monitors, vehicles, network switches, agricultural machinery, medical devices, meteorological devices, household appliances, video recorders, cameras, practically anything.

After the initial attack, the Mirai botnet disabled DynDNS using approximately 100,000 infected IoT devices. [10]

Because of the open-source code, the Mirai botnet has been mutated. The most recent version of Mirai can infect Android-based set-top-boxes and perform DDoS attacks with various methods. [11]

1.2.2 MQTT Attack

MQ Telemetry Transport (MQTT) is an application layer protocol used by remote monitoring and other data collection systems. Since 2016, it has become the reference standard for communication in Internet of Things (IoT) environments. Since more and more people are using it, its operational continuity is becoming more and more important. The protocol uses a publish/subscribe model; the central element is a server (broker), and clients can subscribe to it and will receive data automatically when it is available. The protocol was prepared to handle unreliable network connections. If the channel is broken, the broker stores the messages.

The Slow DoS against Internet of Things Environments (SlowITe) attack is based on the fact that the broker, prepared for slow, unreliable connections, is sufficiently “patient” with clients and does not disconnect from clients even when they are slow. The problem is exacerbated by the fact that MQTT uses TCP (Transmission Control Protocol) for communication.

The attacker initiates the connection with the CONNECT package, and the broker is obliged to maintain the connection for at least 60 seconds by default. To handle these connections, the server must use some resources. Too many connections could cause critical overuse of these resources. Therefore, the number of connections is limited. By creating the necessary number of connections, the attacker can prevent the creation of new connections while communicating with the broker as slowly as possible, thus prolonging the busy state as long as possible.

2 Artificial Intelligence and Botnets

In the last few years, Artificial Intelligence has been developed significantly, and Generative AI can generate – even photorealistic – images, videos and human-like texts. Generative AI is a collective term of different machine learning models and algorithms that can create new works similar to, but somehow different from the input data – basically man-made content – on which they were trained.

Using Long Language Models, the generated text content is surprisingly similar to human-made works; therefore, AI applications can drastically improve the efficiency of normal botnet activities. The following chapters will describe some new opportunities for this new technique.

2.1 Comment or Review Generation

Comments and reviews became important factors in public opinion about specific products or services. The so-called "review bombing" – when a large number of users leave negative comments – method can cause significant damage to any system where users are allowed to leave comments or reviews too easily. This phenomenon forced multiple websites to harden the review algorithms. [12] Generative AIs, with the help of LLMs, can generate human-like text very fast. A botnet operator could use this superb text-generation capability to create fake reviews, comments or other engagement posts to avoid the protective methods and algorithms.

2.1.1 Automated Social Engineering Attacks

LLMs can generate context-aware, highly convincing text. This capability allows the attacker to craft highly targeted, "spear-phishing" email or other social engineering attacks. A botnet could use LLMs to create personalized messages in large volumes that are more likely to trick users into clicking on dangerous links or other malicious content. Most spam and malware filter applications use simple statistical analysis or pattern-based lookup filtering to detect malicious content. Therefore, personalized messages can deceive the defense system.

Another method could be an LLM-capable chatbot. It can interact with the victims on different platforms – like social media or instant messaging systems – and behave like a human peer to extract sensitive information, spread propaganda or deliver malicious software payloads.

2.1.2 Advanced Phishing Attacks

An LLM-assisted botnet can create and deliver highly sophisticated phishing campaigns. It can generate convincing emails or other messages and deliver them

to a forged – seemingly trusted – sender, making it difficult for users to distinguish between genuine and fake messages. Phishing attacks are very popular today, but most of the time, the phishing message is not convincing enough. Many of them contain spelling errors and poor wordings caused by poor translation. With the help of AI, these phishing emails can contain personal information of the victim, increasing the probability of a successful attack.

2.1.3 Disinformation and Manipulation

LLMs can generate fake news articles or social media posts. Botnets could employ AI to create large amounts of false information, contributing to more complex disinformation campaigns. Also, the false information can be amplified by a botnet large enough.

2.1.4 Personalized Scam

Nowadays, many scammers try to deceive innocent victims by spam emails with a special method called “Nigerian scam” or “419 scam”. This scam is based on the gullibility of people, it tries to convince the victim that large inheritance is available, but other transactions must be made before receiving it. These transactions usually involve money transferred to the scammer's bank account. Most of these scams are pretty dumb because all targets receive the same letter, and the content does not fit everyone. But if the attacker uses LLM, every target can receive a personalized letter with fitting data.

2.1.5 Fake Images and Videos

An Artificial Intelligence system can be trained on images and, with the help of advanced algorithms, can generate photorealistic or artistic images. Multiple systems are available today: Midjourney, Leonardo.AI. By generating convincing images and amplifying by a botnet, disinformation can spread quickly. With the current rate of development, separating fake and real pictures could be impossible, which can cause profound problems in society.

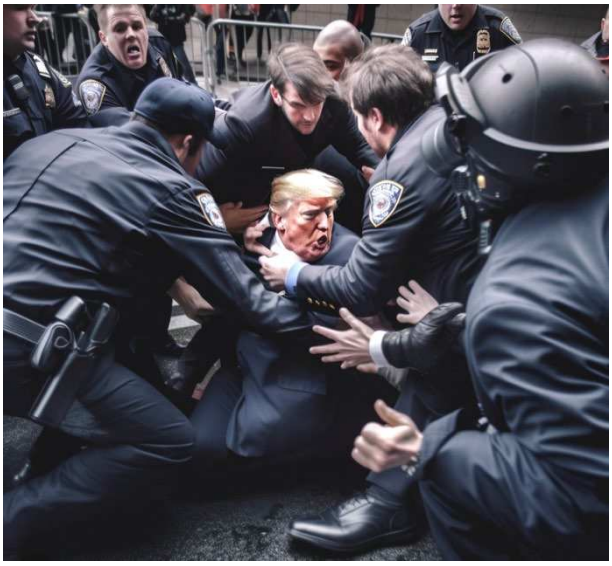

Figure 5
Fake picture generated by Midjourney. Source: Christo Gozev Twitter

Conclusions

The dangers posed by botnets are significant today, and the threat will be increasing in the future. In addition to the "traditional" areas of use – DDoS attacks sending spam – new attempts to influence the functioning of society are becoming more and more significant.

The spread of artificial intelligence is also a separate source of danger: Phishing emails will become less and less recognizable as different language models, such as GPT3 and GPT4, can produce convincing, personalized messages almost instantly. Besides the text content, image-generating systems can produce more and more believable fakes, so fake news is also becoming more and more believable. New problems have also emerged. Many AI systems are trained on data fetched from internet without the permission of the original author, and the copyright issues also work on the opposite side: who is the copyright owner of the generated content?

With the broadly used artificial intelligence applications, more and more content that contains nothing new based on previously existing information will be created. Finding factual, accurate information or honest opinions will become more and more complex, and the AI-generated "noise" will overshadow them.

These problems will generate significant social changes for which everyone should be prepared.

Acknowledgement

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Exploring the Role of Human-Robot Interactions, within the Context of the Effectiveness of a NAO Robot

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Abstract: The NAO robot has been widely used in various settings, from education and healthcare to entertainment and research. The effectiveness of the robot largely depends on its ability to interact with humans in a meaningful and engaging way. This paper explores the role of human-robot interaction in the effectiveness of the NAO robot. We review the literature on human-robot interaction and highlight the key factors that contribute to successful human-robot interactions. Then we discuss the specific features of the NAO robot that facilitate or hinder effective human-robot interactions. Finally, we present some recent studies that have investigated the impact of human-robot interaction on the effectiveness of the robot in different settings. Overall, our analysis suggests that effective human-robot interaction is essential for the successful implementation of the NAO robot, and that further research is needed to better understand the dynamics of human-robot interaction and its impact on the effectiveness of the robot.

Keywords: social robot; NAO; human-robot interaction; education; HRI

1 Introduction

Over the past few decades, the field of robotics has made significant advances in the development of robots that can interact with humans, in a variety of contexts. One such robot is the NAO robot (Figure 1), a humanoid robot developed by the French robotics company Aldebaran Robotics (now part of Softbank Robotics).

The NAO robot has been used in various settings, from education and healthcare to entertainment and research. However, the effectiveness of the NAO robot largely depends on its ability to interact with humans in a meaningful and engaging way. In this paper, we explore the role of human-robot interaction in the effectiveness of the NAO robot. Human-Robot Interaction (HRI) is an interdisciplinary research field that aims to develop a deep understanding of the communication, cooperation and relationships between humans and robots. In recent years, HRI research has made significant progress, including advances in perception, cognition, navigation and communication technologies that have facilitated more effective human-robot collaboration [1] [2]. One of the main goals of human-robot interaction is to enable humans and robots to work together effectively to perform various tasks. HRI research focuses on several areas, such as social interactions, collaboration, learning and adaptation [3]. Researchers use a variety of methods to study HRI, such as laboratory experiments, user evaluations and simulation modelling [4].

2 Related Work

Human-robot interaction (HRI) is a multidisciplinary field that encompasses various aspects of human-robot communication, collaboration, and social interaction. The success of HRI depends on a range of factors, including the robot's physical design, its sensing and perception capabilities, its communication and interaction modalities, and the context of interaction. Some of the key factors that contribute to successful HRI include robot expressivity, anthropomorphism, social presence, and adaptivity. These factors have been studied extensively in the literature, and there is growing evidence that they play a crucial role in shaping human perceptions and attitudes towards robots, as well as the effectiveness of HRI in different domains.

NAO robot features: The NAO robot is a highly expressive and interactive robot, with a range of features that make it suitable for a variety of applications. Some of the key features of the NAO robot include its humanoid form factor, its ability to recognize and respond to human speech, its facial and gestural expressivity, and its programmability and customizability. These features have been instrumental in the NAO robot's success in various settings, but they also pose some challenges for effective HRI. For example, the anthropomorphic design of the NAO robot may lead to unrealistic expectations of its abilities and limitations, while its limited sensing and perception capabilities may hinder its ability to understand and respond appropriately to human cues.

This humanoid robot created by SoftBank Robotics, has been gaining attention in the field of education due to its potential to enhance student engagement and promote active learning. However, there are also several challenges that need to

be addressed when it comes to using NAO robot in education [5]. Here are some of them:

Cost: The NAO robot is an expensive technology, which can limit its accessibility to many educational institutions. The cost of the robot itself is only part of the equation, as schools may also need to purchase additional software and equipment to make the most of the robot's capabilities.

Technical challenges: Using NAO robot requires technical expertise, which may be beyond the capabilities of some teachers and educators. The robot's programming language and software can be complex, and it may take some time for educators to learn how to use the robot effectively.

Limited functionality: While NAO robot has a wide range of capabilities, its functionality is still somewhat limited compared to other educational technologies. For example, the robot's mobility is limited, which may restrict its ability to interact with students in certain ways.

Ethical concerns: As with any technology that collects data, there are ethical concerns associated with using NAO robot in education. Some educators may be hesitant to use the robot if they are unsure how student data will be used, stored, and protected.

Limited research: While there is growing interest in using NAO robot in education, there is still relatively little research on its effectiveness as a teaching tool. As a result, it can be difficult for educators to determine whether the investment in the robot is worth the cost and effort.

Despite these challenges, the NAO robot has the potential to revolutionize the way that students learn and engage with technology. With further research and development, it is possible that many of these challenges can be overcome, making NAO robot a valuable tool for educators in the years to come.

Figure 1
NAO robot

Several recent studies have investigated the impact of human-robot interaction on the effectiveness of social robots in different settings.

For example, a study by Kollar and Vanya found that human-robot interaction cannot be just pessimistic, negative, or only optimistic, maximally accepting and supportive. Robots are constantly appearing in different areas of social life, such as work, private life, public places, offices, the defence. Their conclusion from empirical research is that in the next 10-15 years, a generation will emerge that will socialise with robots, making human-robot interaction increasingly close and emotionally meaningful [5]. As the mobile phone becomes part of everyday life robots will become more and more like human companions [6].

Another study by Tasevski et al. shows the importance of talking for therapy robots and the need for recordings of children-robot interactions to validate this requirement [6]. Not NAO, but also a social robot MARKO (Figure 2) can talk to people by itself, which is important for making children like the robot and use it for therapy. To prove that talking is important for therapy robots, they recorded interactions between children with movement problems and MARKO in a realistic therapy setting. A human-controlled MARKO and made it talk in a therapeutic way in their research process. Their results has been found that the children responded well to MARKO and were motivated to do therapy exercises. MARKO's positive effects go beyond just social interaction, as it also helps children with therapy-relevant nonverbal actions [8].

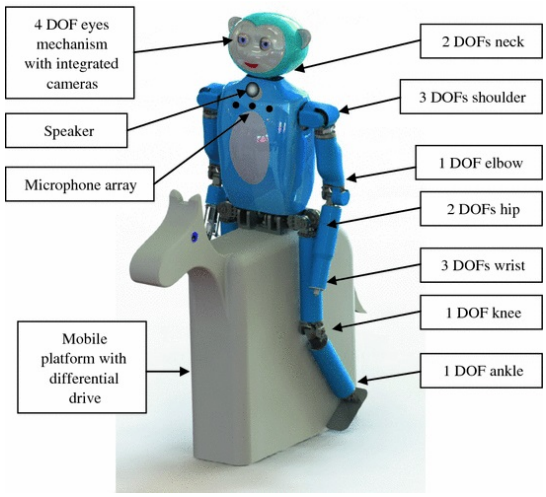

Figure 2
The Human-like robot MARKOt

Sungjin Lee et al. found in their study that robots can be effective tutors for learning English as a foreign language, particularly in improving pronunciation and speaking skills. In their study, the authors investigated the effectiveness of a robot-assisted language learning activity using the robot in improving the pronunciation of English as a foreign language among Korean elementary

students. They found that the robot-assisted activity led to significant improvements in the children's pronunciation and speaking skills [4].

Another study by Cabibihan et al. in 2013 found that NAO robots can help children with autism to understand classroom instructions and improve their engagement in learning activities [5].

Interaction between children and robots in education has been found to enhance both cognitive and affective learning processes, however, there remain some issues that require further investigation. One such challenge is the problem of interaction disorders between children and robot tutors, as the current user interface is mainly based on visual touchscreens. This model is designed to be used for children aged 3-13 years, but cognitive development of children is different and follows a sequential pattern, as described by Piaget's theory of cognitive development. Children progress through four different stages of development, from the sensorimotor stage (0-2 years) to the formal operational stage (11-up). Therefore, a single UI model cannot be used for all ages, especially for pre-operational stage. In the field of Human-Computer Interaction (HCI) research, it is recommended that the UI design must be adjusted to the stage of children's cognitive development. The challenge ahead is to develop a UI design that can be adjusted to the cognitive development of children, to enable optimal child-robot interaction in education, with various roles of robots in education, such as tutors, peers, and tools. Various UI developments in CRI can be reviewed to adjust the UI according to the child's age or cognitive development, such as multimodal UI design which has the potential to develop UI for CRI in education, such as perceptual user interface or attentive user interface by applying various input modalities, such as detection of facial expressions, movements, objects, etc., so that the condition or behaviour of the child can be naturally detected without being limited to touchscreen UI input or tangible user interface [9].

Last but not least, and without claiming to be exhaustive, we would like to highlight the research of Taisuke Nagae and Jaeryoung Lee et al. They write that the advent of new technologies has led to the emergence of supportive robotics aimed at helping children with developmental disabilities achieve greater independence. Traditionally, research on robot therapy involved conducting experiments with the robot out of sight from the subjects. However, a new system has been developed that enables the robot to autonomously recognize the emotions of children with developmental disabilities and provide feedback. This system was designed to quantitatively measure emotional changes in children using skin conductance (EDA) during robot therapy. Results demonstrated that the NAO robot was able to recognize emotions on its own and provide feedback to the subjects. Additionally, a quantitative evaluation was conducted using EDA. By analysing symptoms associated with developmental disorders, there is potential to improve the recognition rate and customize therapy based on individual symptoms [10].

These studies highlight the importance of effective HRI. Drawing on a wide repertoire of literature on HRI, and gathering previous research and conclusions from it, we thought it worthwhile to carry out a SWOT analysis on the subject of effectiveness of human-robot interaction by NAO robot.

3 The Applied Method

SWOT analysis is a widely known strategic planning tool. It helps to understand and identify the application's strengths, weaknesses, opportunities and threats in a given situation. The analysis helps you to look at a given situation from both internal and external perspectives. The internal aspects are strengths and weaknesses, which we can usually influence directly. On the other hand, opportunities and threats, i.e., external factors, are often outside our control. In the following, we will attempt to map the use of the NAO robot as a tool for human-robot interaction through a SWOT analysis [11].

It is one of the most popular and useful methods for evaluating the goals of a project or application and helping to plan its development. The purpose of the analysis is to help you design a strategy that can realistically assess its potential and identify its strengths and weaknesses. This type of evaluation is also able to objectively see the specificities of the interfaces between the service, in our case the human and the NAO robot, and helps to identify the areas where you can get the most out of the use of the robot with the least risk.

In general, it is worth starting the analysis when the service is about to undergo a major transformation, when a new opportunity is emerging, when you want to introduce a new technological innovation or when the social environment has changed. A SWOT analysis is therefore a versatile method of analysis that may be worth repeating at any stage of a development. For NAO robot-related activities, these are the justifications

A ”SWOT” analysis is built up from a matrix of four elements. Each letter represents an internal or external area of the company to be examined:

- **S**trengths focus on the internal, positive attributes of an organization.
- **W**eaknesses identify processes and elements that can be improved.
- **O**pportunities summarize factors over which a firm has no control but can benefit.
- **T**hreats list the elements that can be barriers to success.

A SWOT analysis of using the NAO robot as a tool for human-robot interaction:

Strengths:

- NAO robot is highly interactive and can be programmed to perform a wide range of tasks and activities, making it a versatile tool for human-robot interaction.
- NAO robot is highly customizable and can be adapted to meet the needs of a variety of different users and applications.
- NAO robot is equipped with advanced sensors, such as cameras and microphones, which enable it to perceive and respond to its environment and users.
- NAO robot has a humanoid form, which can make it more approachable and engaging for some users than other types of robots.

Weaknesses:

- NAO robot is relatively expensive, which can limit its accessibility to some users and organizations.
- NAO robot has limited mobility and can only move on flat surfaces, which can limit its use in certain environments.
- NAO robot's battery life is relatively short, which can limit its use in longer interactions or activities.
- NAO robot is limited by its hardware capabilities, which may not be sufficient for more complex tasks or applications.

Opportunities:

- NAO robot can be used in a variety of settings, including education, healthcare, and entertainment, among others.
- NAO robot can be used to assist people with disabilities or special needs, such as autism or cerebral palsy.
- NAO robot can be used to collect data on human-robot interactions, which can be used to improve the design and development of future robots.
- NAO robot can be integrated with other technologies, such as virtual and augmented reality, to enhance the user experience.

Threats:

- NAO robot may face competition from other types of robots and technologies, such as virtual assistants and chatbots.
- NAO robot may face regulatory and ethical challenges related to privacy, security, and the potential for misuse.
- NAO robot may face social acceptance issues, as some people may feel uncomfortable interacting with robots or view them as a replacement for human interaction.

- NAO robot may face technical limitations and challenges related to software development, maintenance, and updates.

4 Human-Robot Interactions in Learning Processes

Technology has played an increasingly important role in education in recent years. One of the most significant developments is the integration of human-machine interaction into the learning process. HMI refers to the interaction between humans and machines, which can take many forms, including chatbots, virtual assistants, educational software, online forums and robots. By applying the elements listed in the SWOT analysis to the NAO robot-supported learning processes, we examined the role of NAO robot in learning processes [14].

One of the main advantages of HMI in the learning process is that it provides learners with access to a wealth of information and resources. Online forums and robots, for example, allow students to ask questions and get answers from experts and other students around the world. This can help deepen their understanding of complex topics and give them new perspectives on the material. In addition, educational software and/or robots can be tailored to the specific needs and learning style of each student, providing them with a personalized learning experience.

Another benefit of HRI in the learning process is that it can increase student engagement and motivation. Interactive software and games prgrammed in robot can make learning more fun and engaging, while chatbots and robots can provide immediate feedback and encouragement to learners. This can help keep students motivated and focused, leading to better learning outcomes.

However, HRI and also HMI has potential drawbacks in the learning process. One concern is that it can lead to a lack of human interaction and socialization. While online forums and chatbots can provide access to a global community of learners, students may miss out on the benefits of face-to-face interactions, such as building relationships with classmates and teachers. In addition, some students may have problems with the lack of personal attention and support they receive in a traditional classroom environment [13-15].

5 Results and Conclusions

Interpreting the strengths of the NAO robot, it can be programmed to do many different things and, thanks to its design, interact with people in many different ways. This makes it a flexible tool that people can use in many situations where

they need the help of a robot. To meet the specific needs of different users or applications, the NAO robot can be customized. This means that people can modify the robot's software or hardware to make it work better in a given situation. It is equipped with advanced sensors, such as cameras and microphones, that allow it to sense its environment and react to events around it. This helps it to be more responsive and interactive with humans. In terms of focusing on the role of human-robot interactions, the NAO's outstanding strength is that it has a human-like form, which can help some people feel more comfortable with it and engage more with it than with other types of robots. Because it has a familiar shape, people can more easily identify with it and understand what it is doing.

The SWOT analysis identifies not only strengths but also weaknesses. In our case, we can highlight the high cost of the robot, which means that it is not available to all users or organizations due to cost constraints. In addition, since it can only move on horizontal, flat terrain, the NAO robot has limited maneuverability, which makes it less useful in environments that are not flat or where it has to climb or navigate through obstacles. In terms of its hardware limitations, it is notable for its relatively short battery life, which may limit the amount of time it can be used in continuous interactions or activities before it needs to be recharged. These limitations and weaknesses may prevent it from performing more complex tasks or applications that require advanced capabilities beyond those provided by the robot.

The NAO robot is versatile and can be used in a variety of fields, including education, healthcare and entertainment. These possibilities mean or imply that the robot can assist in different applications and industries. It can help people with disabilities or special needs, such as people with autism or cerebral palsy. This means that the robot can provide additional support to individuals who need extra help with everyday activities. More generally, the NAO robot can collect data on how people interact with robots, which can be used to improve the design and development of future robots. This means that researchers can use the data collected from the NAO robot to improve the design and functionality of other robots. This can be done by integrating NAO with other technologies such as virtual and augmented reality to enhance the user experience. This means that the robot can be used with other technologies to provide a more engaging and immersive experience for users.

Interpreting the threat claims, it can be concluded that the NAO robot may face competition from other types of robots and technologies, such as virtual assistants and chatbots. This means that the robot will face challenges in terms of market competition and may need to differentiate itself from other similar technologies.

In other respects, the NAO robot may face regulatory and ethical challenges related to privacy, security and the potential for abuse. This means that regulatory and ethical considerations will need to be taken into account in the future to ensure the safe and responsible use of the robot. It may also be associated with

social acceptance problems, as some may feel uncomfortable interacting with robots or see them as a substitute for human interaction. This means that there may be resistance from some individuals or groups who are reluctant to accept robots as part of their daily lives.

From a technical perspective, the NAO robot may face technical limitations and challenges in terms of software development, maintenance and upgrades. This means that the robot may require ongoing technical support and updates to ensure that it continues to function properly and meet user needs. In addition, software development of the robot can be challenging and may require continuous investment in research and development (Figure 3).

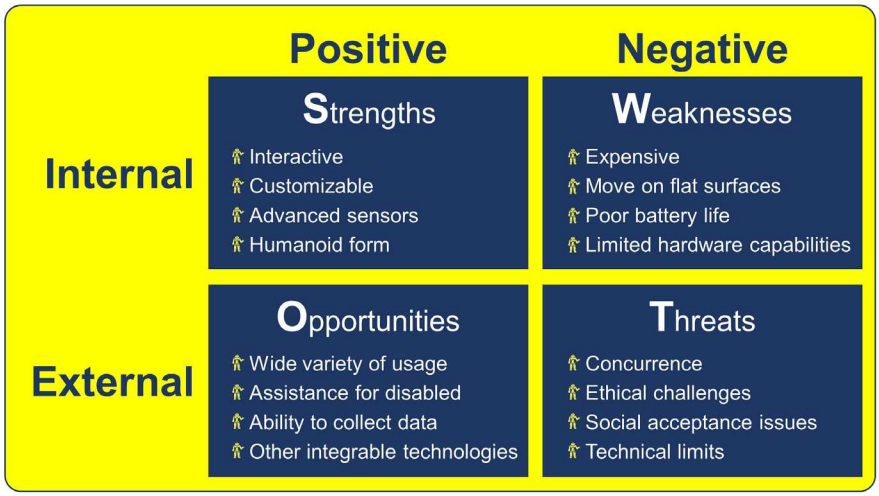

Figure 3
SWOT of effectiveness by NAO

6 Summary and Options for the Future

The NAO robot is designed to interact with humans in various contexts, including educational settings, research environments, and public spaces. The robot is equipped with sensors, cameras, and microphones that enable it to perceive and respond to human actions and speech.

Several studies have examined the human-robot interaction aspect of the NAO robot, and the findings suggest that the robot is effective in engaging with humans and eliciting social responses [12].

For example, a study conducted in a primary school in Italy found that the NAO robot was able to elicit social and emotional responses from young students, such as laughter, smiles, and positive facial expressions. Similarly, a study conducted in a retirement home in the Netherlands found that the NAO robot was able to engage with elderly residents and stimulate social interactions, which in turn led to improved well-being.

However, the human-robot interaction aspect of the NAO robot is not without challenges. For example, some studies have found that the robot's speech recognition and natural language processing capabilities can be limited, which can affect the quality of interactions with humans [16][17].

Overall, the human-robot interaction aspect of the NAO robot has shown promise in enhancing social interactions and well-being in various contexts, but further research is needed to address the challenges and improve the robot's capabilities in this area [18][19].

In summary, HRI has the potential to revolutionize the learning process by providing students with access to a wealth of information and resources, increasing engagement and motivation, and providing a personalized learning experience. Potential disadvantages of HRI, including the lack of human interaction [20-22] and socialization, as well as the costs of implementing and maintaining these tools, must be considered. Ultimately, the key to successful HRI-based learning is finding the right balance between technology and people.

The importance of human-robot interfaces will become increasingly important in the world of work and education as a result of digitalization processes. The efficiency of the human-robot interface can be further developed in the present and in the future on the basis of artificial intelligence, for which the technical conditions are already in place. Learning, then self-learning, and finally AI-based robots will help to set future trends, the exploitation of which for educational purposes will also become increasingly important. This is particularly true in education in STEM fields [23-25] Some researchers have already begun studies in which humanoid robots are used to help students learn healthy lifestyles and basic skills. [26-27].

As a continuation of the empirical research work that has been started, future experiments will also explore and analyze the limitations of the NAO robot and the current shortcomings of the technology.

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Playing Computer Games and Playing Sports in the Light of Personal Background Variables

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Abstract: The eighties of the last century, saw significant an acceleration in the development and improvement of computer games. In this study, the sports habits of the people sampled, were examined, to see whether these habits are related to their attitudes towards video game use. The extent to which time spent playing active sports, affects the amount of time spent playing video games, was also analyzed. During all three hypothesis tests, it was, therefore, possible to establish, that based on personal background variables, differences can be observed, regarding sports habits and time spent playing video games. At the same time, the time spent on video games, does not come at the expense of playing sports. Those who play more video games do not do less sport, neither in terms of gender, age group or even place of residence.

Keywords: sports; computer games; personal background variables

1 Introduction

The eighties of the last century saw significant acceleration in the development and improvement of computer games. This development has now grown into an industry we call eSports. In addition to institutionalized e-sports, where there are teams, fans, sponsors, a large number of international competitions and live broadcasts, there is of course another type of video gaming that primarily meets individual needs [7]. The de-regulation of the broadcasting sector has decisively determined the development and popularization of online video games [17], while eSport found an

ally in streaming [4]. In addition to existing social media networks and video sharing platforms, streaming platforms, such as Twitch, also started to appear.

The worldwide coronavirus pandemic significantly reduced the attendance of traditional eSports events; however, the popularity of online games remained unbroken. These facts are well supported by the sales statistics of the hardware (primarily video cards) required for online games [14].

It is important to highlight that communities built around an online game create a real subculture, which is different from the mainstream. It is characterized by two essential things: verbal expression and ritual elements of subculture [7]. The unique language associated with each game is primarily related to the environment/world where the game takes place, but it also has its own abbreviations for situations, tactics and strategy, and various commands.

In the case of online games, we can define a number of different genres, the most popular of which are Multiplayer Online Battle Arena, First Person Shooter and Real Time Strategy. In general, it can be said that communication, cooperation, creativity, teamwork and choosing the right strategy appear in each genre. This is because each player has their own role within the team, which they consciously develop, while they also try to get into a situation where they can give as much as possible to the team, as well as to the development of their own character.

"The physical element and social function of sport which have come to the forefront in case law and academic debates are relevant to the question of eSport's status as a sport" [2] [18].

It is not difficult to observe the same terminology appearing in eSports and traditional sports, such as player, tactic, team, strategy, game, match, offense, defense, practice, skill, and others that are frequently in use. Moreover, "competitive video gamers start to demonstrate the same athletic properties as traditional sports athletes" [4].

When it comes to computer games, people's first association is passive and relaxing activity, which greatly contributes to the fact that eSports are recognized as a real sport. Contrary to popular opinion, there is evidence that eSports athletes exhibit signs that could be considered physical exertion [8]. In [1] Aadahl, Kjaer and Jorgensen state that "absolute intensity may also be expressed as a multiple of an individual's basal metabolic rate (MET=metabolic equivalent)".

Although the players do not perform any spectacular movements while playing online games, the movements of the fingers on the mouse and keyboard are significant. Nowadays, everyone can use online tools to test how many mouse clicks they can do in a minute or a second. In the case of computer games, this process does not consist only of clicking, but is aimed at carrying out real actions and commands, so the mechanical functions are complemented by cognitive functions as well. The unit for measuring this skill is called Actions Per Minute (APM). For example, a prepared player performs around 400 APM, while the highest ever

measured is 818, which is more than 13 commands issued in a second, using a keyboard and mouse. Pimenta [10] points out that the whole process is asymmetric, since players use both hands (keyboard + mouse) which means that different parts of the brain are active. These values are several times what can be measured among average people, but they are also higher than the values of elite athletes. For example, these values are higher than those of professional table tennis players, who have the highest values for hand-eye coordination.

The German Sports University tests the levels of the hormone, cortisol produced in the players' bodies, and has found that the amount of cortisol produced is roughly the same as that of a race car driver. In addition, the players' heart rate is often 160-180, which is the same as the heart rate measured in marathon runners. Considering these empirical data, it cannot be said that the body of e-athletes is not exposed to the same effects as traditional athletes [11] [12].

We are witnessing the transformation of a significant part of casual gaming into a serious industry characterized by prize money, sponsors, strict rules, teams, referees, live streams and huge arenas. Of course, this also has psychological effects, which are primarily experienced by eSports athletes.

Perhaps the most remarkable of these are the beneficial effects on health from a physiological point of view: taking part in sports improves the functioning of the heart and circulatory system (blood vessels become more flexible and the heart muscles become more stable), and the heart rate also decreases; the oxygen absorption capacity of the respiratory system increases; movement coordination improves; while sports also have a beneficial effect on the nervous system and the immune system; as well as helping to achieve and maintain an appropriate body weight, which are only some of the most important benefits [3] [5].

From a psychological perspective, the increase in self-awareness (for example, motivation, endurance and fighting ability) and self-confidence, the reduction of feelings of anxiety and tension, and the improvement of focus and concentration are worth highlighting. At the same time, it also helps in achieving emotional balance, improves the quality of sleep and general well-being, and results in a sense of joy and feelings of success [3] [5].

In terms of self-evaluation, it can be said that the athlete is able to at least partially utilize the experiences gained during sports in other areas of their life as well. Sports activities contribute to the development of the individual, the strengthening of their health, the development of their physical abilities and movement sets and patters, as well as to a meaningful and productive use of free time [16].

Mahoney believed that the role of sports in children's lives is significant in terms of their personality development, because the activities that build a child's competence are particularly critical in shaping their development, since children at a young age monitor their own performance and competence with increased focus [6] [13]. Research has established that physically active young people eat healthier

and smoke less, watch less TV, spend their free time more usefully, and their risk of becoming overweight also decreases. [8] [15].

It can be concluded that their well-being is also better, and an improved state of fitness and health can be seen during the various measurements, so sportsmanship can also be paralleled with a better quality of life. Those who play sports are also more satisfied with their lives and report fewer depressive symptoms. Attitudes towards values can also differ between children who play sports and those who do not: adolescents who regularly play sports prefer internal value orientation methods (e.g., self-acceptance, belonging to a group, sense of community, physical health), while young people with low activity levels value external value orientation methods. (e.g., financial success, good looks, reputation) [9] [12]. Some researchers have already started studies using humanoid robots to help students adopt healthy lifestyles [19] [20].

2 The Aim of the Research

Computer games and sports are both types of activity that involve different personal background variables, and individuals' preferences may vary depending on their individual preferences, interests, health and other factors. We define some key background variables that may affect the propensity to play computer games and sports. Examples include interests and preferences, time and flexibility, health, community and peer relationships, or goals and motivation.

In this study, the sports habits of the people in the sample were examined, to see whether these habits are related to their attitudes towards video game use. The extent to which time spent playing active sports affects the amount of time spent playing video games, was also analyzed.

During the data analysis, the gender, age and place of residence of the participants was also taken into account, examining whether a correlation can be demonstrated with regard to the personal background factors, as well as physical sports activities or habits related to video games.

2.1 Hypotheses

H1: The intensity of playing sports is inversely proportional to the frequency of time spent playing computer games.

H2: A distinction can be made in the sample on the basis of the individual background variables in terms of whether the examined persons choose active sports or video games as a free time activity.

H2/a: Women spend significantly more time playing active sports, compared to men, who prefer to spend more time on computer games.

H2/b: Among the younger age group, it is more common to spend their free time with online video games, in contrast to the older age group, who choose active sports more often.

H2/c: Being in a city provides more opportunities for sports, so people living in the city spend more time playing active sports, as opposed to people living in the countryside, who prefer to spend more time on computer games.

3 Method

The quantitative questionnaire survey received a total of N=485 evaluable responses. Simple random sampling was used to reach our target group using the snowball method.. The survey was conducted using a questionnaire method, and the questionnaires were published online. The questionnaire contained 14 questions, 3 of which related to the personal background information of the participants in the survey, examining the composition according to gender, age and place of residence.

Another 5 questions asked about sports habits, and 5 asked about habits related to video games and online games.

3.1 Sample of Research

A total of 485 people participated in the research. Gender: 46% of survey participants are male (N = 224) and 54% are female (N = 261). Age: The average age of the survey participants is 20 years old. Participants were divided into three groups based on their age (Table 1).

Table 1
Distribution of the age groups

	N	**%**
Younger than 14 years	154	32
15-20 years old	185	38
Older than 21 years	146	30
Total	**485**	**100**

Country: The vast majority of respondents, 98% (N = 475), are from Serbia. Another 2% (N = 10) live in Hungary. Residence: Regarding their municipality of origin, 62% (N = 300) of the sample come from cities and 38% (N = 185) are from villages.

4 Results

4.1 Correlations between Time Spent Playing Sports and Playing Online Video Games

82% of the sample (N=400) answered that they do sports regularly, with varying intensities. Only 18% of the sample (N=85) indicated that they do not partake in sports at all. Regarding the intensity of playing sports, the majority of the participants, 33% (N=160), enjoy sports on a daily basis for at least 1 hour. 28% (N=137) exercise for less than an hour per day, and 21% (N=103) exercise for more than 1 hour every day (Table 1).

Table 2
Frequency of doing sports

	N	**%**
Do no sports	85	18
Do sports less than 1 hour a day	137	28
Do sports 1 hour a day	160	33
Do sports more than 1 hour a day	103	21
Total	**485**	**100**

The time spent by the sample participants playing online or offline video games shows the following: the majority of the respondents, 39% (N=189), simply do not play online games. 14% of them (N=68) play monthly and 18% (N=88) play on a weekly basis. The remaining respondents, 29% of the sample (N=140), on the other hand, play online or offline video games on a daily basis (Table 2).

Table 3
Time spent playing video games

	N	**%**
Do not play video games	189	39
Plays on a monthly basis	68	14
Plays on a weekly basis	88	18
Plays on a daily basis	140	29
Total	**485**	**100**

Most of the participants in the study who play video games frequently (N=277), 45% (N=89) have been playing regularly for 1-5 years. 45% of the respondents (N=89) have been playing video games for less than a year, and 23% (N=63) have been playing for more than 5 years (Table 3).

Sports habits were also compared with the frequency of time spent playing video games (Table 4).

Table 4
How long have you been playing video games?

	N	%
Less than 1 year ago	89	32
1-5 years ago	125	45
More than 5 years ago	63	23
Total	**277**	**100**

The data show that, contrary to the initial assumption, a little over a half of the non-athletes, 52% (N=44), do not regularly play video games; while this proportion for athletes is 56% (N=41), which, on the other hand, is less than half for this group. The proportion of non-athletes who play daily is 26% (N=22), while for athletes this proportion is roughly the same, 24% (N=32).

Table 5 shows the amount of time spent playing video games by athletes and non-athletes. Out of the total sample, athletes accounted for N=137, which means that they play more than one hour of sport per day. The number of non-athletes was 263, who play less than one hour of sport per day.

Table 5
Time spent playing video games among athletes and non-athletes

	Athlete		Not an athlete	
	N	%		
Do not play	56	41	44	52
Plays on a monthly basis	24	17	7	8
Plays on a weekly basis	25	18	12	14
Plays on a daily basis	32	24	22	26
Total	**137**	**100**	**85**	**100**

Comparing the data, it can be observed that there is no difference between the data for athletes and non-athletes regarding the time spent on computer games (Fig. 1).

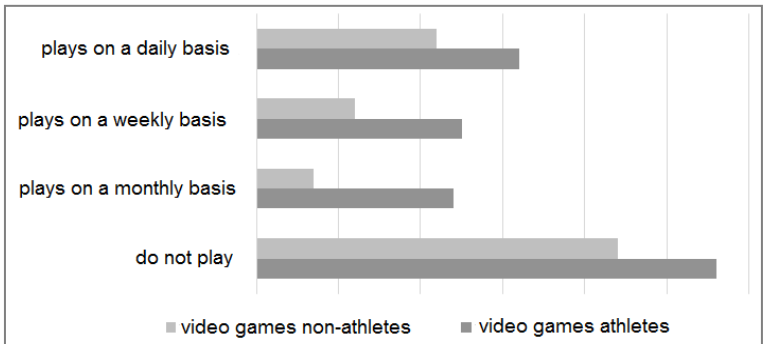

Figure 1
Time spent playing video games by athletes and non-athletes

An additional study was conducted, using a two-sample t-test, which also supported the above results, according to which, there is no significant difference between athletes and non-athlete in terms of time spent playing video games (t=1.29 p=0.02).

According to the statement formulated in the first hypothesis, the intensity of sports is inversely proportional to the frequency of time spent with computer games. The acquired results were compared using the Pearson's correlation test. The obtained values show that there is a correlation between the two variables, but they are directly proportional to each other, meaning that the frequency of playing sports increases or decreases with the frequency of time spent playing video games. At the same time, the value of the correlation coefficient is r=0.13 (p=0.003), which indicates a negligible relationship between the variables.

Based on the results obtained, in the case of H1, the statement included in the hypothesis is to be rejected.

4.2 Sports Habits and Video Gaming in The Light of Personal Background Variables

4.2.1 Gender Characteristics of Time Spent Playing Active Sports and Playing Video Games

In this study, the amount of time spent by men and women playing sports and using video games was compared, as well as the intensity of sports and the use of online video games. Based on the results, 64% of the men in the sample partake in sports for at least one hour a day, while 46% of women answered that they spend at least 1 hour a day doing sports activities (Table 6). The difference in the time spent on non-sports shows a significant difference based on the values of the two-sample t-test (t=4.81 p=0.001). The data supports the idea that men spend significantly more time doing sports than women. The obtained results alone, however, do not support the H2/a hypothesis.

Table 6

How much time do you spend doing sports? (by gender)

	Men		**Women**	
	N	**%**	**N**	**%**
Do not doing sports	31	13	54	21
Less than 1 hour per day	51	23	86	33
1 hour per day	71	32	89	34
More than 1 hour per day	71	32	32	12
Total	**224**	**100**	**261**	**100**

In terms of time spent using video games, a significantly lower proportion of women, 61%, do not play video games at all, compared to only 14% of men who do not play video games. Only 1% of women play more than one hour a day, and 13% of men belong to the same category (Table 7). Regarding the frequency of playing video games, there is a significant difference between men and women, also based on the results of the two-sample t-test (t=14.9 p=0.001). According to this, women spend significantly less time playing video games than men. This result, on the other hand, supports the statement contained in the H2/a hypothesis.

Table 7
How much time do you spend playing video games? (by gender)

	Men		**Women**	
	N	**%**	**N**	**%**
Do not play	31	14	158	61
Less than 1 hour per day	100	44	92	35
1 hour per day	64	29	7	3
More than 1 hour per day	29	13	4	1
Total	**224**	**100**	**261**	**100**

Examining the data from the perspective of age groups, the results indicate that non-athletes are more common among older age groups. A significantly higher proportion of those younger than 15, and the 15-20 age group take part in sports regularly, 1 or more hours a day, than those older than 21 (Table 8, Figure 2).

Table 8
Characteristics of the time spent doing sports and playing video games in terms of the examined age groups

	Under 15 years of Age		**Between 15-20 Years**		**Over 21 years of Age**	
	N	**%**	**N**	**%**	**N**	**%**
Do not play	21	13	32	17	32	22
Less than 1 hour per day	38	25	51	28	48	33
1 hour per day	57	37	52	28	51	35
More than 1 hour per day	38	25	50	27	15	10
Total	**154**	**100**	**185**	**100**	**146**	**100**

The obtained results were checked with a one-way ANOVA test, the values of which (F=6.47 p=0.002) show that the age group older than 21 years plays sports significantly less than the younger ones: [younger than 15 years; 15–20-year-olds] > [over 21 years old]. These results refute the H2/b hypothesis, which claims that the older age group spends more time on active sports.

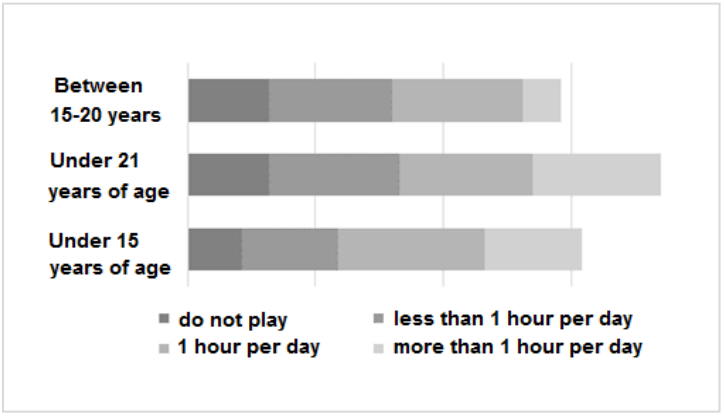

Figure 2
Sports habits by age group

Regarding the frequency of time spent with video games in each age group, the youngest age group appears to be the one who spends the most time playing games (Table 9). Those younger than 15 spend an average of 2.14 hours a day playing video games, those between 15 and 20 play 1.68 hours, and those over 20 play 1.11 hours a day. The obtained results are also supported by the one-way ANOVA test (F=14.64 p=0.001), based on the values of which, the following relationship can be determined in regards to time spent on video games: [under 15 years old]>[between 15-20 years old]> [Those over 21].

Table 9
How much time do you spend playing video games? (by age group)

	Under 15 years of age		**Between 15-20 years**		**Between 15-20 years**	
	N	**%**	**N**	**%**	**N**	**%**
Do not play	40	26	68	37	81	55
Less than 1 hour per day	74	48	76	41	42	29
1 hour per day	28	18	24	13	19	13
More than 1 hour per day	12	8	17	9	4	3
Total	**154**	**100**	**185**	**100**	**146**	**100**

The obtained results support a part of the statement contained in the H2/b hypothesis, according to which it is more common among the younger generation to spend their free time with online video games.

4.2.2 Characteristics of Time Spent Playing Active Sports and Playing Video Games in Terms of Place of Residence

The study examined whether participants living in the city or from villages do sports activities more often. The assumption was that there are more opportunities for sports in the cities, so the people living there spend most of their free time partaking in some kind of sports activity. Based on the data, 35% of the participants living in the city exercise for at least one hour a day, and 25% of them do so for more than one hour. Among the people living in villages, 30% of the respondents do sports for at least one hour a day, and 15% of them do so for several hours a day (Table 10). The differences were also supported by the two-sample t-test based on the two groups (t=3.28 p=0.001). This means that people living in cities spend significantly more time playing sports than people living in villages. This result confirms the statement contained in the H2/c hypothesis.

Table 10
How much time do you spend playing sports? (by place of residence)

	City		Village	
	N	**%**	**N**	**%**
Do not do sport	47	16	38	20
Less than 1 hour per day	73	24	64	35
1 hour per day	104	35	56	30
More than 1 hour per day	76	25	27	15
Total	**300**	**100**	**185**	**100**

In terms of time spent playing video games, 16% of city dwellers play at least one hour a day, and 7% play more than one hour. 42% play less than an hour a day, and 35% do not play at all. 12% of the people living in villages play for one hour a day, while 6% of them play more than one hour. 37% play less than one hour a day, and 45% do not play video games at all (Table 11). Looking at the average of the results obtained, city dwellers spend 1.8 hours a day playing video games, as opposed to village residents, who spend 1.4 hours a day playing video games. Based on the results of the two-sample t-test (t=2.42 p=0.01), this difference can be considered significant. These results refute a part of the hypothesis H2/c, according to which people living in villages spend more time on computer games.

Table 11
How much time do you spend playing video games? (by place of residence)

	Men		Women	
	N	**%**	**N**	**%**
Do not play	105	35	84	45
Less than 1 hour per day	125	42	67	37
1 hour per day	49	16	22	12
More than 1 hour per day	21	7	12	6
Total	**300**	**100**	**185**	**100**

Conclusions

The first hypothesis stated that the intensity of sports is inversely proportional to the frequency of time spent on computer games. The results do show a correlation between the two variables; however, it is a direct correlation instead, meaning that the frequency of playing sports increases or decreases with the frequency of time spent playing video games. Therefore, the obtained results do not support the statement contained in the H1 hypothesis.

Based on individual background variables, the sample was examined to see if the participants prefer sports or video games as free time activities.

Based on the results of the gender survey, it can be said that men spend significantly more time playing sports than women, which refutes the first half of the statement included in the H2/a hypothesis. At the same time, women actually spend significantly less time using video games than men, which confirms the other part of the hypothesis.

The tests carried out based on age groups also confirmed only the part of the H2/b hypothesis, according to which it is more common among the younger generation to spend their free time with online video games. Older people really do play less, but also do less sports activities than young people.

According to the study based on place of residence, people living in cities spend significantly more time playing sports than people living in villages. However, it is also those living in the city, who play video games more often.

During all three hypothesis tests, it was, therefore, possible to establish that based on personal background variables, differences can be observed regarding sports habits and time spent playing video games. At the same time, the time spent on video games, does not come at the expense of playing sports. Those who play more games do not play less sports, neither in terms of gender, age group or place of residence.

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Theoretical and Practical Issues of Learning Support, in Teacher Training

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Abstract: Lifelong learning is a basic requirement, in all areas in our rapidly changing world. One of the most important pillars of lifelong learning, is the teaching of learning by transferring basic knowledge of learning methodology, developing learning and thinking skills, through "self-knowledge discoveries", that are associated with learning and by developing self-regulated learning. In this process, an important role is played by those methods, techniques and digital applications, that result in effective and successful learning, by adjusting to the learning style, habits and strategies of students.

Keywords: self-regulated learning; learning methodology; online applications; effective learning

1 The Role of Learning Support in the Development of Self-regulated Learning

"If there is a lack of interest, curiosity, activity joy in learning, if purposeful efforts do not increase performance day by day, if the student does not feel that they are taking over the world more and more this way, the school will become a compulsive institution in which neither the student, nor the teacher can feel good."

(Péter Oroszlány) [1]

According to Endréné Réthy, the education process as a complex, interactive process, includes not only the process of teaching and learning, but also the process of building and developing of cognitive self-regulation and motivational self-regulation. In this process, not only the active processing and effective acquisition of the curriculum (cultural goods) should take place during the joint activities of the teacher and the student, but also the student's ability to learn autonomously, their cognitive self-regulation and the high-level self-regulation of their learning motivations. However, all this happens if the teaching material in the education process is mediated in a pedagogically justified differentiated dosage and by taking the regularities of learning into account, ensuring continuous feedback and

motivation, with the active participation of students, and if, at the same time, the teacher takes into account the composition of the class, the individual characteristics of the students, their level of development, their prior knowledge and experience, the nature of the curriculum and their own methodological possibilities. [2] According to Endréné Réthy, "We can talk about self-regulated learning when a person motivates himself and plans, structures, directs and controls his learning activities independently and self-responsibly." [3] In the development of this not only the conscious and differentiated planning and organization of the education process plays a central role, but also the teaching of learning and the establishment of the basics of learning methodology.

All these would be increasingly necessary, but unfortunately not enough emphasis is put on them in the practice of education today.

Unfortunately, the thoughts of Árpád Lappints, published in 2002, in which he explains that a significant part of the students, unfortunately do not like and cannot learn, are still valid today. Their typical characteristic is that mechanism prevails both in learning and in recalling, even if it is not justified. In many instances, they do not know the importance of learning techniques, learning methods and strategies, and they do not even seek to learn and apply them. Another typical characteristic of them is that they do not differentiate between different contents and there is an excessive extent of adaptation to the method of assessment. Another bad innervation is that learning habits and methods do not change with advancing age, and learning failures gradually lead to the lack of learning activity. [4] If we add the challenges of our present time to this, we can also see that the digital competences of the digital generation are very different. Despite the online education period, young people leaving high schools use various digital opportunities and applications very modestly to facilitate their own learning, according to our experience [17] [21].

1.1 The Most Important Phases of Teaching Learning

According to Endréné Réthy, the most important phases of teaching learning include *getting to know the individual learning methods of students, discussing and developing together the correct individual learning methods:* supporting and helping the conscious rethinking of individually applied learning methods is of high importance. She also emphasizes in her work that *the purpose of introducing various learning styles, techniques, strategies and ways is to* help the students find the most effective one for them. *Ensuring the psychological conditions of learning* is of great importance: the "ritual" attunement to learning, the permanent place of learning, the optimal order of the things to learn (from the moderate through the most difficult to the easiest), the use of multiple sensory channels during learning (e.g. reading, representation, listening, telling, discussing), the forms of various breaks, alternation of learning activities, the "brave" transformation and problem-solving of things to learn, the use of aids, the initiation of factors that impede

learning, the application of multiple forms and tricks of self-checking, e.g. trial telling, summarizing the essence, explanation of keywords, and self-reward after successfully completing a more difficult learning task. [2]

A prerequisite of effective learning is that each student finds the most effective subject-dependent learning techniques and tricks for themselves [12]. Teachers also have an important role in teaching learning, namely, providing students with differentiated and well-prepared tasks, as well as providing additional learning opportunities and learning aids. Another task is to incorporate the necessary individual correction procedures: to apply corrective, supplementary, remedial, compensatory, preferential procedures. [2] In the age of digital culture, these processes must be completed with a system of digital tools related to learning style and learning strategy [18] [28]. There are several good practices today in the use of different applications in education, either related to augmented reality-based learning or in relation to VR education spaces. [5-11] [26] [27] [29] [30]

1.2 Learning Support in Teacher Training

In case of students entering higher education, we often find that despite the fact that there are many resources and help available to them through the World Wide Web, frameworks and applications that promote online learning, it does not somehow result in more effective and enjoyable learning. In higher education dropout campaigns try to help young people, during which, in addition to pedagogical methods and the organization of learning, it would be important to offer students a "menu" – given their learning habits and strategies – to successfully meet the various challenges. In teacher training, we pay a special attention to the topic, since prospective teachers need to be prepared to support the learning of the children entrusted to them. However, based on our experience, this has to start with them, which requires a high degree of self-knowledge, as well as the acquisition of techniques and methods, that can make their own learning activity more effective.

2 Research into Learning in Teacher Training

The paper presents the initial phase of a research. The aim of the research was to map whether the pedagogical students enrolling in our study programs had dealt with learning methodology during their studies so far, what they think about learning and teaching as future teachers. How do they see the effectiveness of learning, teaching? What assumptions do they have about the issue? This paper also tries to interpret all of this, in relation to online education.

2.1 Analysis and Method

The data collection by means of questionnaire took place in the autumn of 2020. A total of 64 first-year, full-time students (teacher of special education study program (37 students), teacher training study program (19 students), social pedagogy (8 students) filled in the online questionnaire. The questionnaire can be divided into more parts, the first group of questions recorded impressions of learning, teaching and knowledge, as well as questions related to their experience with learning methodology. The second group of questions investigated thoughts on effective learning, namely, what the key to effective learning might be, and what motivates them the most in learning. It was also asked where the role of the teachers is seen the most in this process. The next group of questions concerned specific remarks about teaching, effective methods, and judging the success of lessons. The final questions of the questionnaire revealed the status of online education in the pandemic period (pre-graduation period), as well as the difficulties related to it.

The present paper highlights some areas of this research, without claiming to be exhaustive.

2.1 Hypotheses

Hypothesis 1: Students enrolling in our study programs participated to a small extent in learning methodology classes during their previous studies.

Hypothesis 2: The use of different digital possibilities and applications as well as the knowledge of their role in learning support requires development.

Hypothesis 3: Students can very well delineate the factors of pedagogical effectiveness with their laical pedagogical experience.

2.2 Results of the Questionnaire Survey

With regard to the questions if they had studied learning methodology as a separate subject during their primary and secondary school years, 90.6% of the students answered no referring to primary school, 6.3% did not know and 3.1% answered yes. Referring to secondary school, 78.1% of the students did not deal with learning methodology in a separate subject, 4.7% did not know and 17.2% participated in such a lesson. Although in secondary school the number of those who received support in learning in this form increased, this number is still very negligible. In my opinion, much more emphasis should be placed on this area. It has a key role in reducing dropout rates, strengthening learning motivation, maintaining interest in learning, shaping self-esteem and self-reflection, defining learning goals and successfully navigating the path to reach the goals.

With regard to the question, "*Write down the 5 words that first come to your mind about learning.*" (Figure 1), I mostly found positive approaches and terms.

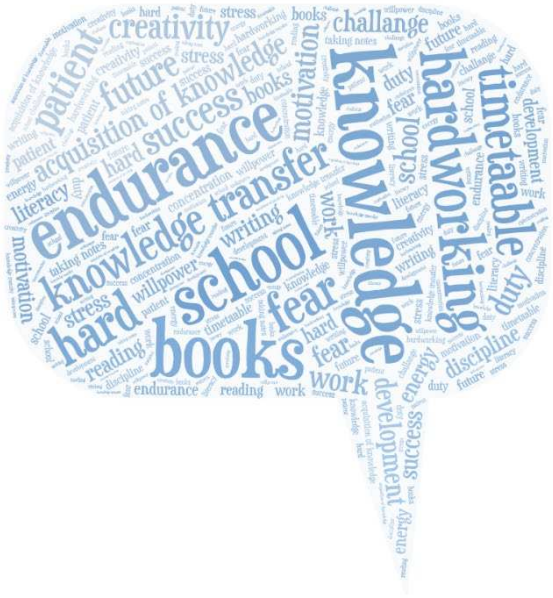

Figure 1
Word cloud about concepts that come to the respondents' mind about learning (own compilation)

The most frequently mentioned term was knowledge, knowledge-transfer followed by perseverance, then diligence and scheduling, then books, school and knowledge acquisition, development were highlighted. Mostly positive or neutral expressions were mentioned, however, some more negative ones like difficulty, monotone, tiring, stress, anxiety, struggle also appeared. Many expressions were associated with personal qualities such as creativity, confidence, willpower, patience, discipline. Terms like future, opportunity and success were added to another group. Among the answers, several concepts were related to learning methods and techniques, such as note-taking, making figures, highlighting in color, practicing, revising, swotting. It is a very good result that basically positive attitudes were reflected in the responses of the teacher candidates.

Regarding the question, *"What does learning mean to me?"*, very exciting answers were given. The majority of them were related to development, prosperity, and positive impressions, which can be a good starting point in teacher training. As an illustration, here are some answers to this question: *"Expanding our knowledge, openness to the world, broadening our perspective in several areas"; "It means spiritual fulfilment, a positive thing for me."; "I like learning new things in a way that I can recall them later."; "It means a kind of challenge that I want to fulfil."*.

Of course, more negative approaches were also found in some cases. *"Learning has always meant something mandatory that, as much as I can remember, I have never enjoyed, or have never thought it would teach me good, pleasant, or overly useful things".* Our important aim could be to change these attitudes, to create and support positive learning experience.

Figure 2
Word cloud about concepts that come to the respondents' mind about teaching (own compilation)

With regard to the question, "*Write down the 5 words that first come to your mind about teaching.*" (Figure 2), similar concepts were mentioned as in the case of learning.

The most frequently mentioned expressions about teaching was also knowledge-transfer. The second most frequently mentioned term was patience followed by the concepts of profession, knowledge, responsibility, attention, creativity, love, challenge, and child-centeredness. They were followed by the concepts of joy, playfulness, wisdom, difficulty, experience, perseverance, empathy, definiteness, and upbringing. The other terms mentioned were related to school tools and methods, as well as to assessment methods and learning techniques.

With regard to the question, *"What is it that helps you learn effectively?"*, the different learning styles of the students were very clear, as the factors related to the different learning styles (e.g., movement, silence, peers, music) as well as the methods and techniques applied in practice (e.g., note-taking, revising, explanation, drafting, figures, highlighting in color) were mentioned.

In the research I also sought for an answer to how teacher training students think about effective methods with their laical pedagogical views and previous experience.

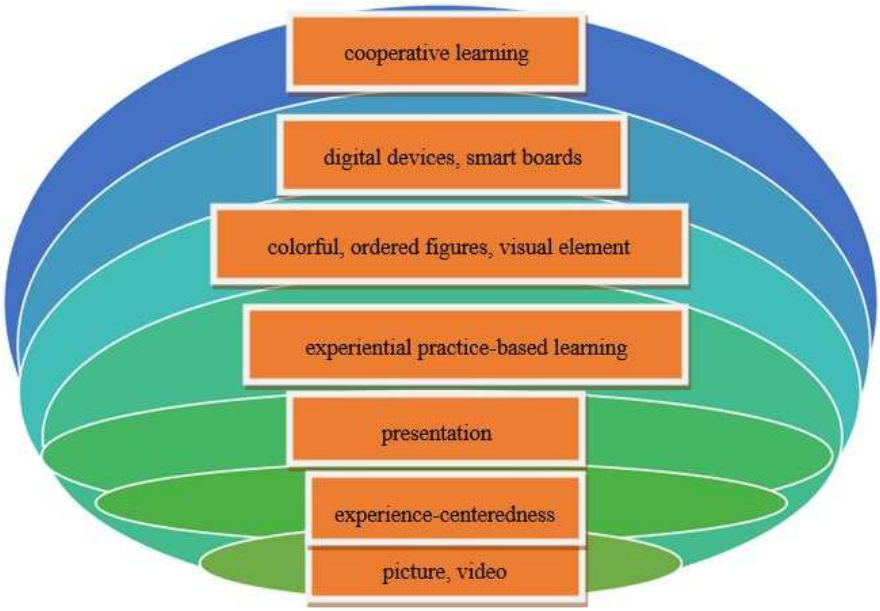

Figure 3
What are the most effective teaching methods based on your student experience so far?

Figure 3 illustrates the students' answers in groups. Answers given to the open-ended question were categorized, with the largest group being collaborative group work. *"Interactive, group tasks as you can effectively gain experience from others."* The next large group of answers was related to digital devices and the use of smart boards. The third large group consisted of answers in which colorful, ordered figures, visual elements were highlighted. Another high proportion of answers highlighted interactivity as well as experiential practice-based learning. The next large group consisted of lectures, presentations, then experience-centeredness, and the use of pictures and videos.

Some combined different methodological elements in their responses:

> ***"The exact draft dictation of the teacher, and then the gathering of the students into small groups where they discuss the already dictated draft together."***
>
> ***"Playful, experience-based curriculum elaboration. Practice by repeated revising. Joint elaboration of a given problem with the peers. Practical tasks related to everyday life."***

"Using electronic boards, making presentations, the playful elaboration of the curriculum, teamwork."

"The teacher should not only give the curriculum orally to the students, but also should project the outline of the issues on the board and should help students learn by illustrating pictures. It is easier to learn the curriculum if we use more senses during learning."

"This includes the countless options provided by the Internet, including video-sharing interfaces and sites."

"For me, experiential learning or having as many examples as possible to explain the given topic, and a visual or musical approach helped me learn faster."

"Combining subjects and study them as a whole is also an excellent method."

There was a respondent who emphasized the importance of the teacher's personal experience, own examples and way of seeing things in the lectures.

It can be seen from the responses of the digital generation that they have a need for group work, projects, interactive, experience-based learning that supports collaboration between students and teachers.

In this context, their experience with cooperative methods was also investigated.

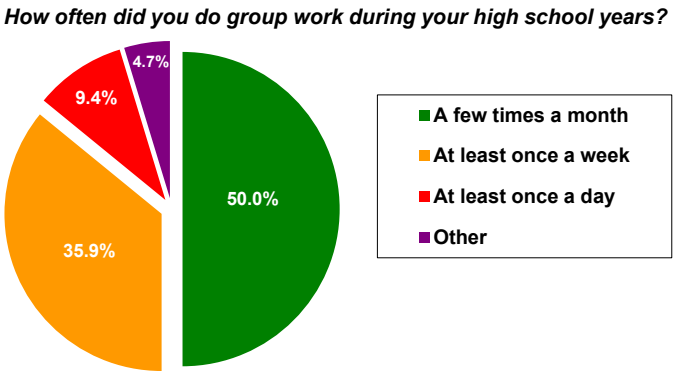

Figure 4
Frequency of group work during high school years

Answers given to the question, '*How often did you do group work during your high school years?'* (Figure 4), show that 9.4% of the students did so at least once a day, 35.9% of them did so at least once a week, whereas 50% of them did so a few times a month. Nobody marked the answer, 'in each lesson'. These data show what we perceive at the beginning of their higher education studies, namely that students have very little experience in group work, the division of labor in the group as well

as individual responsibilities in the group work are less known to them. This area needs to be developed in higher education, since it is an important and necessary key competence in the labor market.

In the rest of the questionnaire, questions related to online education were formulated. With regard to the question, '*What was the hardest thing for you in the time of online education?*', a lot of students mentioned the lack of explanations from the teacher in connection with the lack of lessons held online (many teachers sent tasks, materials to be processed individually via email). A significant proportion of the respondents reported the difficulty of time management, and the lack of face-to-face interactions. The lack of attention and motivation, as well as the length of time spent in front of the monitor were also a problem for many. The respondents also lacked 'tangible', practical learning. One respondent also stressed the difficulty deriving from the integration of private and professional life:

"*Being at home itself means that online education has ruined the concept of home*"

With regard to the question, '*How would you describe your own online learning in three words?'*, I tried to organize the concepts into categories, however, I did not succeed in doing so, because it was impossible to create explicit categories based on the answers given. Nevertheless, it is informative that 97 concepts are negative, and only 62 are positive. Most of them mentioned difficulty, but time-consuming, monotone, tiring, impersonal were also mentioned as negative concepts. Stress, anxiety, loneliness, under-motivation, and little help from the teacher were also among the responses. Positive concepts mentioned were as follows: independence, a sense of freedom, purposeful, challenging, enthusiastic, eager, prepared, diligent, successful, time-saving, accurate, organized, conscientious. One student highlighted that "*It is a personalized Heaven for people who prefer hiding*". We have very mixed experience with online education, but based on the answers it can be said that there is need for improvement in this area too.

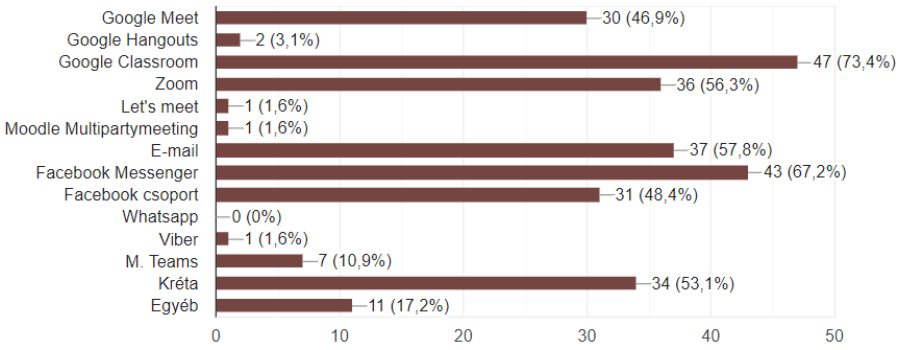

Figure 5
Forms of communication (keeping in touch) with teachers

Figure 5 illustrates the answers given to the question, '*What opportunities were used to communicate/keep in touch with your teachers in the spring semester?*'. The most popular forms of communication were Google Classroom, Facebook Messenger, email, Zoom, Kréta, and Google Meet. Skype and Discord were mentioned among others.

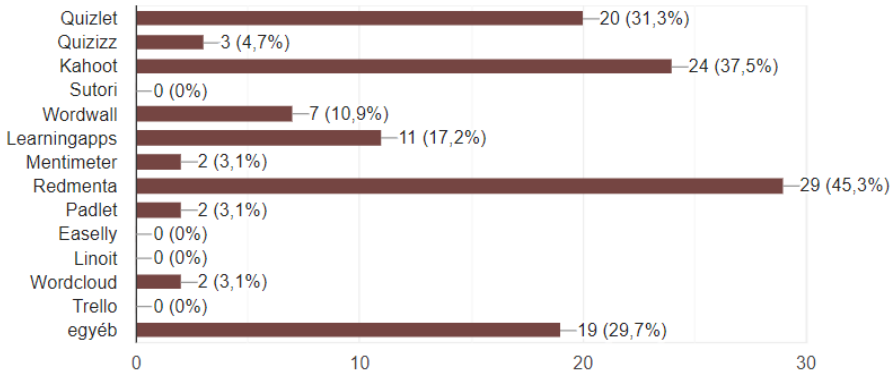

Figure 6
Applications in online education

The most commonly used applications (Figure 6) included Redmenta, Kahoot, and Quizlet, but some students have also encountered Learningapps and Wordwall applications. 13 students did not use any application supporting learning during the online learning period. This is quite sad, as excellent programs and digital tools help young people's learning activities, enabling them to have diverse, creative learning and practice.

In answering to the question, '*What do you think are the benefits of online education?*', students most frequently highlighted the concept of own time management and comfortable environment, and the fact that they did not have to travel. They saw their own time management and greater freedom, the fact that everything is available on the Internet as benefits. Several students said that it was a good option not to be left behind in case of an illness, and that it was a good solution in the pandemic situation, but more people said that it was only good for being a temporary solution. Several respondents reported that they did not see the benefit.

In answering to the question, '*What do you think are the disadvantages of online education?*', students mentioned several factors.

The biggest disadvantage mentioned by the respondents was the lack of personal contacts, interactions and direct help from the teacher. Many students reported the lack of exercise, health hazards (spinal disorders, eye deterioration), technical problems, the loss of motivation and interest, and a lot of abuse made by students.

"Live human relationships are no substitute for online contact. Thus, the motivating effect of the community ceases. Less stimuli. There is no boundary between 'school' and free/home time. It is unhealthy to spend so much time in front of a screen."

"Not everyone has enough independence, not everyone has the infrastructure, a supportive environment."

Responses included lack of motivation, inattention, dispersion, inaccuracy, and fatigue.

3 Some Applications Supporting Learning

3.1 Systematization, Process-Planning with Sutori

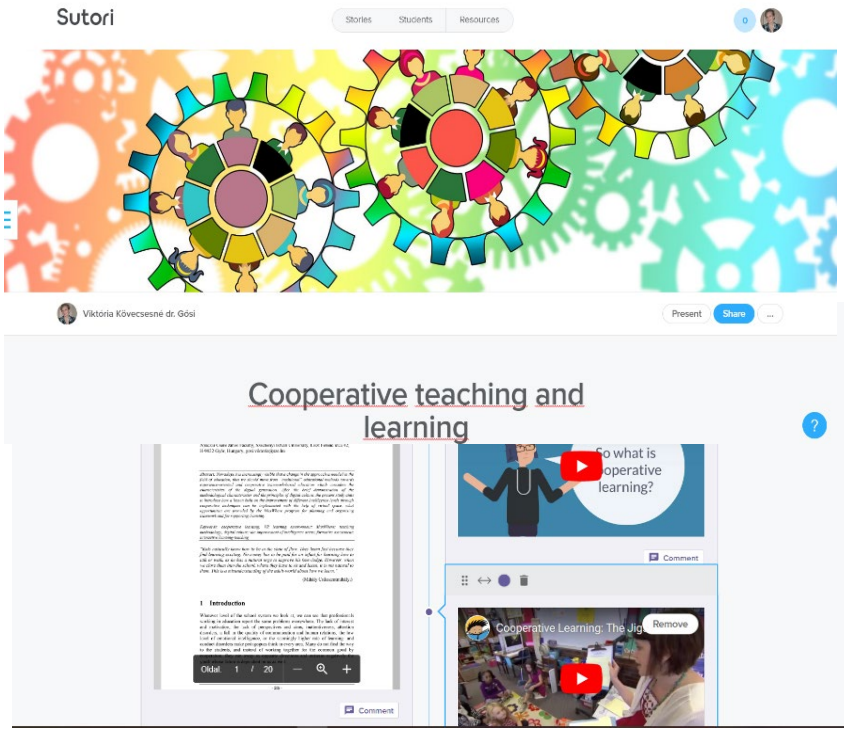

Figure 7
Processing the topic of cooperative learning with Sutori program (own compilation)

I try to incorporate the possibilities provided by digital devices in my work. Sutori (Figure 7) is a more and more popular program among students, which is very effective, as we can plan the lesson process along a vertical timeline from attunement and motivation through curriculum elaboration and meaning creation to reflection and evaluation. Several types of documents, videos, and useful applications can be built into the process, with reflections and chat options. The tasks placed in the windows can be easily downloaded, the curriculum can be built on a good logical order, it allows for various curriculum elaboration and, last but not least, it responds to the visual needs of the digital generation. After use, students highlighted that "it is applicable, easy to edit, and share for all ages". Many students reported that it was good to be able to "go through the material as a process" and that "the surface was easy to handle". An important aspect for them was that "it included a wide variety of written and oral sources and thought-provoking tasks." [11]

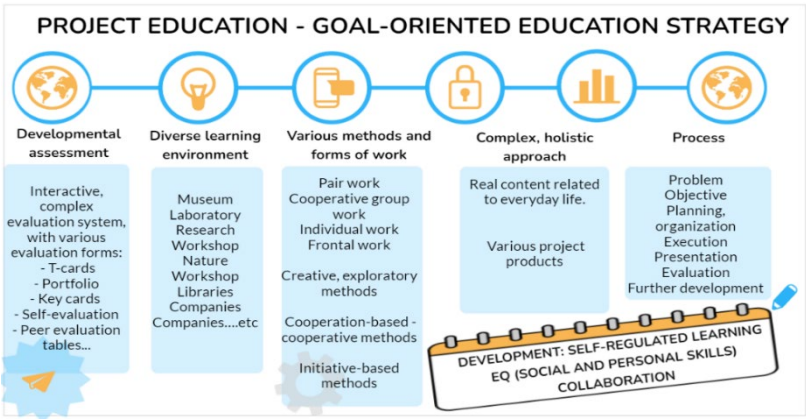

Figure 8

Illustration and logical systematization by making infographics (own compilation)

From the viewpoint of learning methodology, it is also useful to create posters that illustrates the essence of what we have to say with figures and graphs, in addition to effective note-taking techniques and keyword-making. It can also be used to elaborate new curriculums, but also to synthesize existing curriculums. The easel.ly program (http://easel.ly) or Genially (https://app.genial.ly/dashboard) is a good opportunity for students to learn the proportionate display of visual and textual information, and the editing of digital graphs. [16] In their work, teacher candidates can choose from posters with different styles and themes for the subjects they teach according to the themes. A similar program developing creativity is Designcap. (www.designcap.com)

3.2 Creating a Word Cloud with Wordart Program

Figure 9
Word cloud for systematizing the topic of cooperative learning (own compilation)

There are several programs available (www.wordart.com, www.tagul.com, www.tagxedo, www.wordle.net) with the help of which we can create a word cloud (Figure 9). It is also an application that can be integrated into almost all stages of the teaching – learning process. These programs provide a very good opportunity to summarize and highlight the keywords of a topic. We can arrange the keywords into various shapes. The shape, the colors, the content all increase the effectiveness of learning.

3.3 Learning Definitions Playfully with Quizlet Program

In recent years, as a university lecturer, I have experienced that the acquisition of basic definitions of didactics, which is the basis of the pedagogical language, is becoming increasingly difficult for teacher candidates. To solve this situation, I found the Quizlet (Figure 10) (www.quizlet.com) application, with which we can provide learning methodological support to our students. This currently partially free web and mobile application has grown out of the idea of digitizing classic two-sided learning cards. [15] They can practice the definitions in several 'modes' and even test their knowledge at the end of their learning.

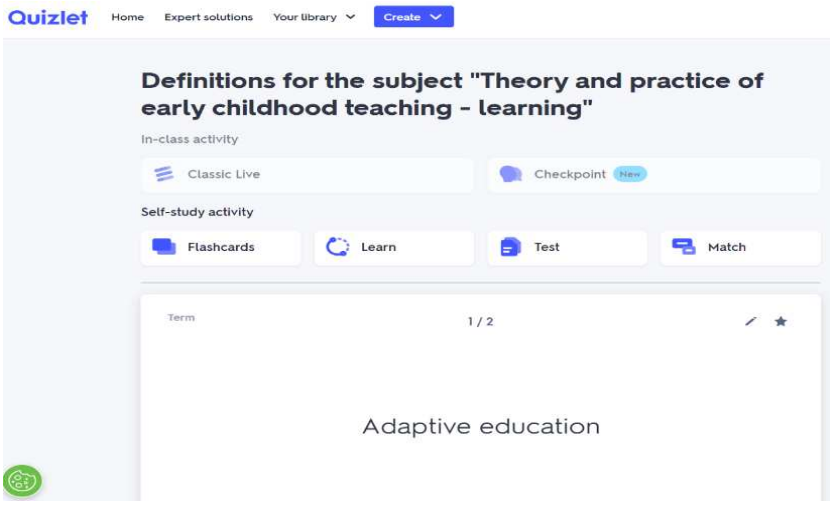

Figure 10
Memorizing definitions with Quizlet game (own compilation)

3.4 Playful Learning with Quizzes https://quizizz.com, https://kahoot.com/schools-u/

The quiz-making programs also support playful learning and practice. Kahoot (Figure 11) and Quizizz are popular among teacher candidates. Their ease of use, playful appearance, and structure based on excitement and anticipation make them popular. [15]

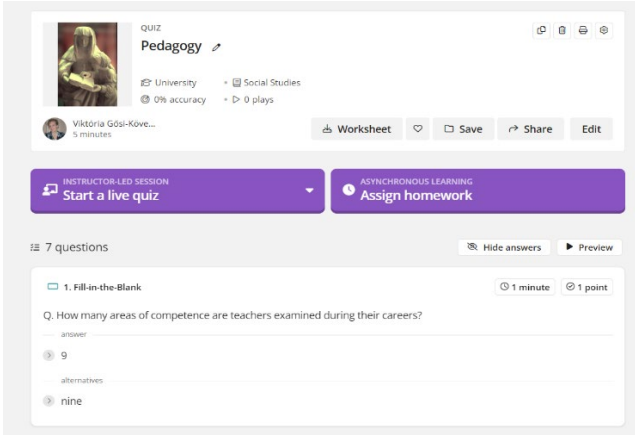

Figure 11
Quizziz (own compilation)

3.5 Joint Project work on Padlet Interface (www.padlet.com) and Application of Message Boards (http://linoit.com)

The digital form of corkboards is the easiest way to create and collaborate. [15] A number of goals can be achieved with the use of Padlet interface. The 'message wall' with diverse background and a wide range of layouts provides opportunities for communication, project work and cooperative learning. People assigned to the interface can write comments, upload different documents related to a topic, or even task solutions. In my experience, teacher candidates are very happy to use this application.

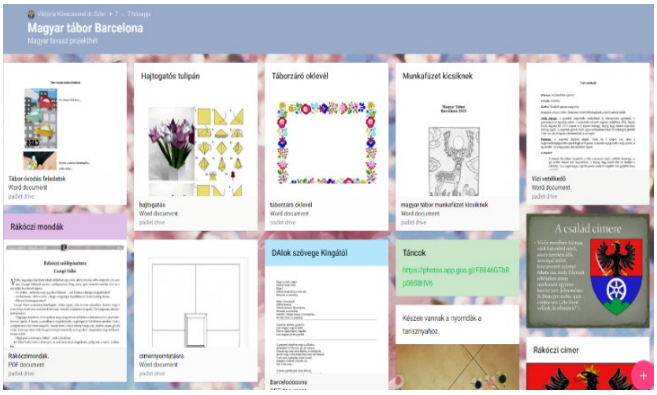

Figure 12
The Padlet interface of Hungarian Spring Project Week (own compilation)

On this interface we can place the results of our project work, the most important pieces of information, plans, shared tasks, and project results. The advantage of this interface is that it is easy to use, a wide variety of document types can be placed on it, and it is easy to review.

3.5 Offline Project with Online Support with MaxWhere 3D VR Background

At Széchenyi István University, several curricula have recently been developed in MaxWhere 3D VR spaces. [22] The spaces are perfectly adapted to the learning characteristics of the digital generation. The efficiency factors highlighted by first-year students, like visual stimuli, colorful, well-arranged curriculum and virtual educational spaces that meet the transparency criteria, can help ensure this [20]. The effectiveness of MaxWhere 3D virtual spaces has been proven by several studies in recent times. [24] [25] During my pedagogical practice, I tried out a project related to environmental education and forest pedagogy, in the first part of which we dealt with the topic in the forest school, but parallel to this, we also

worked with an online interface, 3D virtual space. During the work, the students received the basic documents, films and quizzes necessary for the implementation of the project in a space compiled by me and arranged with information and tasks, which purposefully helped the elaboration of the topic, providing an opportunity for further research. I chose the 'Team member' space for this purpose.

Different spaces have different layouts, and the number of smartboards varies. Depending on whether you want to do a lecture, a practical session, project work, or cooperative group work, or just a simpler presentation, you can choose from the spaces. We can insert Pdf documents, chat programs, videos, applications that can be used effectively in education (Kahoot, Quizlet, Redmenta, Wordwall, Learningapps, Sutori) into the smartboards [19].

The teacher can invent a 'learning room' arranged in a space, in which they can place important background information and task descriptions related to the topic according to a given logic. This 'learning room' was available for the students to support the completion of project assignments. During self-regulated learning, the students are able to create spaces according to their learning goals, supplemented with applications that support their learning activities in accordance with their learning style and habits.

Figure 13
'Team member' MaxWhere 3D VR space (own compilation)

By elaborating and displaying pedagogical projects in a 3D VR space, I believe that we can support, not only individual learning paths, but also group work. [23] This makes the arrangement and processing of information in the case of a given topic, more efficient and transparent, and the multilateral elaboration of the topic and the expansion of digital opportunities, during the elaboration of the project, can be a motivation for the students as well. [13]

Conclusions

In the course of my research, my aim was to show what ideas first-year students, starting in teacher education, have about learning and teaching and how they consider effective teaching-learning methods. Although there are many good applications, it is thought-provoking, that no students highlighted, among the benefits of online education, that programs/applications could be effective for learning in a classroom education. I believe that it is our task to learn these tools and to make students aware of their roles and functions in higher education.

During my research, my first hypothesis proved to be true. The students who enrolled in our study programs, did indeed, take part to a smaller extent in learning methodology classes during their previous studies, thus, this area is unfortunately not emphasized enough in education. My second hypothesis was also confirmed, as the use of different digital opportunities and applications, the knowledge of their role in supporting learning requires development. We have to put greater emphasis on this during the training, in addition to the classical learning techniques and methods.

The examination of my third hypothesis showed that students had a fundamentally positive attitude towards learning and teaching, however, the same could not be said about online education. It could be also seen from their answers given to the questions, that they could very well delineate the factors of pedagogical effectiveness, with their laical pedagogical experience.

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Estimating Battery Life in TDMA Mesh-based Wireless Sensor Networks, for Merged Data Collection Method

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Abstract: This paper provides a comprehensive description of battery life estimation and energy consumption in TDMA wireless mesh sensor networks. Specifically, we focus on the merged data collecting (MDC) method that utilizes lithium thionyl chloride batteries. We present detailed timing, energy consumption, and battery life estimation results of the MDC method in TDMA mesh sensor networks that use flooding routing. Our battery life estimation is based on actual energy consumption measurements, of the sensor nodes during various communication phases, using a realistic battery model. We also determine low-level constraints based on energy consumption measurements during different operational phases. To demonstrate the applicability of our model, we applied it to a test sensor network designed for temperature monitoring.

Keywords: wireless network energy consumption; WSN; battery life estimation; merged data collecting; MDC; IQRF; FRC; TDMA; flooding routing

1 Introduction

Wireless sensor networks are increasingly being used in food manufacturing for process monitoring and quality assurance. In compliance with HACCP requirements that mandate daily temperature recording in manufacturing facilities and storage spaces. In such facilities, sensor networks are designed to automate temperature recording without disrupting the manufacturing process or generating dust. As a result, wireless sensors with battery power supplies are often the best option. However, accurate battery life estimation is crucial for planning maintenance periods in field applications. Energy consumption reduction is one of the biggest challenges in battery-powered wireless sensor networks. This paper proposes a battery life estimation method for TDMA mesh-based wireless sensor networks (WSNs) utilizing merged data collection technique.

TDMA-based wireless mesh sensor networks are widely utilized in industrial fields due to their deterministic media access. Popular network technologies such as WirelessHART or ISA-100 utilize graph routing for efficient point-to-point routing [17-20]. Various studies have discussed energy consumption estimation for these networks [34-37].

The IQRF network technology relies on flooding routing to send broadcast messages across other networks. Although flooding routing is not the most efficient method for point-to-point messaging, it is a reliable and efficient technique for sensor data collection in wireless sensor networks (WSNs), especially when using the merged data collection method. In previous studies, we have highlighted the benefits of merged data collection in TDMA WSNs [1] and introduced a deep sleep algorithm that reduces the energy consumption of sensor nodes [2].

The optimal network topology for a specific use case depends on the RF (Radio Frequency) range of the wireless technology being used. The star topology is the simplest wireless topology and is suitable for point-multipoint networks, as long as the RF range of the gateway can cover the entire facility [6] [7] [22]. However, in cases where sensors are located in a cold storage built from metal materials, the RF range of low-power wireless devices may not cover the entire facility. In such cases, mesh or tree network topologies enable nodes to route communication messages throughout the network, thereby extending the RF range of the entire network. In a mesh or tree network topology, nodes retransmit received packets through the routing procedure, and the number of message retransmissions is measured in hops, where each hop represents one retransmission [15]. Multi-hop wireless mesh communication technology can efficiently cover the entire manufacturing area.

Figure 1 illustrates a sensor network application installed in a manufacturing facility. The objective of this sensor network is to automatically collect data from sensor nodes in compliance with HACCP requirements, which mandate the daily recording of temperature. However, some companies may need oversampling for quality assurance purposes every hour or even every 15 minutes [5]. In IQRF networks, the discovery process assigns a Virtual Routing Number (VRN) to nodes within the network. A breadth-first search algorithm is used during the discovery process to lease VRN addresses. The VRN address indicates the routing distance from the network coordinator and defines the dedicated time slot for nodes during the routing procedure [15] [22]. Figure 2 displays the network graph for the test network, along with the logical addresses and VRNs.

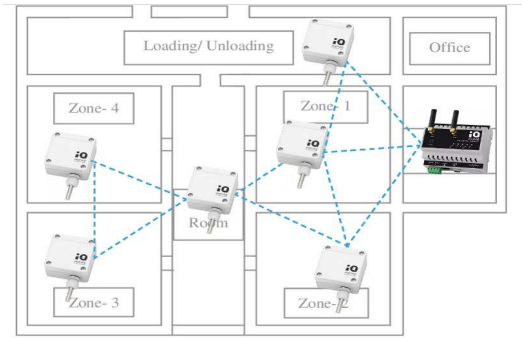

Figure 1
Installed test sensor network

Temperature values can be recorded in a wireless sensor network by collecting data from the sensor nodes. The data collection can be initiated either by the sensor nodes themselves or by the network coordinator. If the sensors initiate data transmission, it is asynchronous with the rest of the network. This can lead to collisions in TDMA networks due to possible time slot overlapping. However, collisions can be avoided through synchronization.

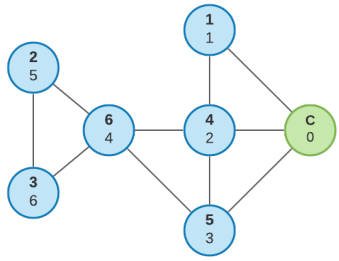

Figure 2
Wireless mesh sensor network graph with logical addresses (top) and VRNs bottom)

There are several ways to implement synchronization in a sensor network. One option is to use super frames, similar to WirelessHART networks [17]. Another approach is to use a request-response pattern where the data collection is centralized and the wireless network coordinator always initiates communication. With this approach, the sensor nodes don't require additional synchronization for network initialization. Centralized data collection simplifies the process and eliminates the possibility of synchronization issues.

2 Merged Data Collection Methods for Wireless Sensor Networks

Flooding routing can be a slow but robust and reliable routing mechanism, especially in dense routing networks. In a previous paper [1], we compared different data collection methods in IQRF-like networks. Our test sensor network demonstrated the usefulness of simultaneous data collection, and we compared centralized data collection methods like polling, synchronized broadcast response, and merged data collection. We evaluated these methods based on the duration and number of transmissions per node.

The merged data collection method leverages flooding routing in TDMA mesh networks. The concept is to send measured sensor values in one response packet as a broadcast request to the entire network. This method works best when a small amount of data is collected from each node. The message payload size depends on the number of nodes collecting sensor data. For temperature sensor data, this method only collects one byte from each node. In IQRF, the payload size is 64 bytes, which can collect merged data from a maximum of 64 nodes [10].

The merged data collection method begins with a request broadcast packet. When the last node receives this packet, it transmits its response in its time slot. Other nodes continue to transmit sensor data in their designated time slots, similar to flooding routing. Each node merges the received packet payloads and inserts their own measured value into the appropriate byte in the payload based on the address. When the coordinator receives the final packet and merges it, the measured sensor data is available at the designated byte in the packet payload.

IQRF's implementation of the Fast Response Command (FRC) extends the data merging algorithm by including an additional non-routing packet transmission. Before the response is routed through the network, each node sends its own data as a beacon message. This transmission allows all neighboring nodes to receive the sensor data of the node. The non-routing packet is intended to support non-routing devices that lack a VRN number and is sent in a time slot based on the logical addresses of the nodes. In a fully discovered network, this results in duplicated transmission of responses, which enhances the reliability of data collection [15] [22-24]. The duration of merged data collection varies depending on the network size:

$$t_{MDC} = N(t_{req} + t_{MDCresp}) + t_{proc} \tag{1}$$

where $t_{MDCresp}$ is the time slot of the response packets. As per the IQRF specification [15], the larger packet size causes a longer time slot due to the increased propagation time. Therefore, the merged data collection method has a time complexity of O(N), where N represents the number of nodes in the network.

Compared to merged data collection, the Fast Response Command (FRC) with additional data transmission has a longer duration. The duration of FRC data collection in a fully discovered network is [15] [16]:

$$t_{FRC} = N \cdot t_{req} + t_{FRCresp}(N+2) + t_{proc} + t_{Cproc} \tag{2}$$

As depicted in Figure 3, the merged data collection method is significantly faster than polling or synchronized response in larger networks.

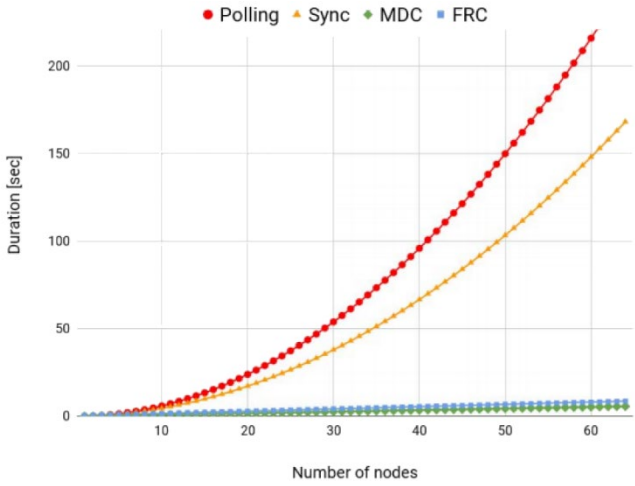

Figure 3
Duration of data collecting methods based on the TR-76D timings [16]

3 Sensor Node Energy Consumption in Wireless Sensor Networks Using Merged Data Collection Methods

In order to estimate the battery life of sensor nodes, we first needed to define their energy consumption when using Merged Data Collection (MDC) methods. For this purpose, we used the Fast Response Command (FRC) method, which we found to be more reliable in field applications, as we have previously described in [1]. Furthermore, the energy consumption of MDC can be reduced by removing the non-routing beacon sending phase. To simplify the energy consumption estimation, we replaced low-level constraints, such as hardware and driver limitations, with actual measured energy costs. In Wireless Sensor Networks (WSNs), high-level constraints, such as network communication, have a significant impact on energy consumption. The communication cycle of sensor

nodes can be divided into well-defined phases, as shown in the current diagram of two sensor nodes in Figure 2. The phases are:

- Deep sleep
- Idle
- Request Broadcast Message Routing
- Processing: reading sensor values
- Sending non-routing beacon packets
- Response message routing

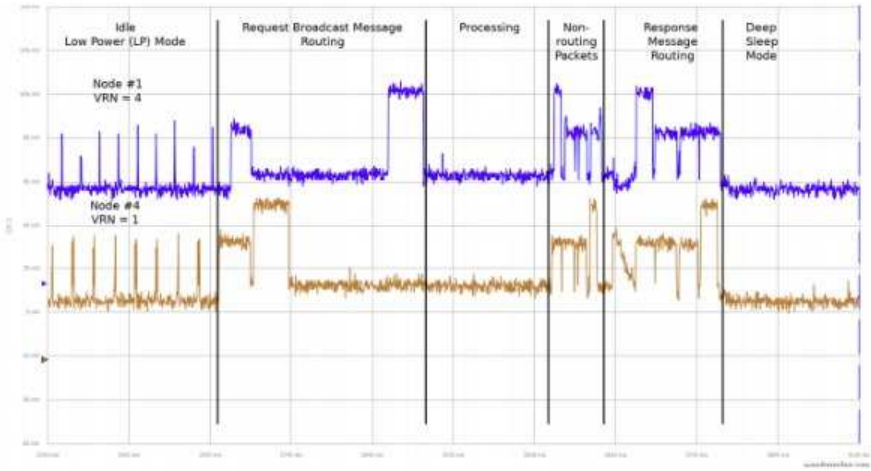

Figure 4
Measured current of TR-76D modules divided into phases [16] of nodes 1 and 4 during FRC data collecting method

Nodes in the idle state are capable of receiving incoming messages. Upon receiving a request message, each node repeats it in its own time slot as defined by flooding routing. Once the packet transmission is complete, the node disables its transceiver module to avoid receiving anything until the end of the routing. This ensures that each node in the network receives the message. In the next processing phase, the nodes can process the incoming request, acquire sensor data, and must complete this task within a predefined time.

The total energy consumption of a sensor using synchronized deep sleep:

$$E_{total} = n_r E_{FRC} + E_{dsleep} \tag{3}$$

The total energy consumption of the FRC merged data collecting method can be calculated as the sum of the energy consumption in each phase:

$$E_{FRC} = E_{idle} + E_{request} + E_{proc} + E_{beacon} + E_{response} \tag{4}$$

Table 1
Variables used in the energy consumption model described in this paper

Variable	Description
E_{total}	Energy consumption of the node
E_{FRC}	Energy consumption of FRC data collecting cycle
E_{idle}	Energy consumption in idle mode
$E_{request}$	Energy consumption of the request broadcast routing
E_{proc}	Energy consumption of message processing and sensor acquisition
E_{beacon}	Energy consumption of the beacon sending
$E_{response}$	Energy consumption of the response routing
E_{dsleep}	Energy consumption of deep sleep mode
U	System voltage
I_{Rx}	Current of RF receive mode
I_{Tx}	Current of RF transmission mode (at max output power)
I_{LP}	Current of idle LP mode
N	Number of network nodes without the coordinator
n_r	Number of requests per data collecting cycle
t_{req}	Timeslot for request message
t_{resp}	Timeslot of response message
t_p	Duration of synchronization preamble
t_{proc}	Message processing time
t_{dsleep}	Duration of deep sleep mode
t_{qsleep}	Sleep quantum (2.097s at IQRF deep sleep)
t_{period}	Periodic request interval
t_{FRC}	Total duration of FRC data collecting
t_{idle}	Duration of idle mode before FRC request
t_{bc}	Duration of beacon non-routing
t_{bcw}	Pause after beacon sending

We make the assumption that the power supply circuit is shared among the sensor components, and the system voltage level is dependent on both the discharge characteristics of the lithium thionyl chloride batteries and the voltage regulator applied in the sensor node, as described in references [15] [26].

Deep Sleep Mode

In a previous paper [2], we described the synchronized deep sleep mode as a technique for extending battery life in sensor networks that use centralized data collection. This mode reduces energy consumption by disabling the transceiver module and putting the sensor nodes into deep sleep mode until the next data collection period. As depicted in Figure 2, the deep sleep mode is activated simultaneously in all nodes after the FRC data collection is completed. The duration of the deep sleep period is determined by the system's requirements and is typically optimized for energy savings. The deep sleep time is:

$$t_{dsleep} = t_{period} - t_{FRC} \tag{5}$$

To ensure stable communication, it is crucial for sensor nodes to switch from active to idle mode before receiving requests in the next data collection cycle. If a sensor misses a request, it remains in idle mode until the next one, leading to increased energy consumption. Moreover, it is essential to ensure that the sleep time is shorter than the period time. Figure 5 illustrates the proper and improper operations of the synchronized deep sleep algorithm. In case a node misses a request, it cannot route the packet, leading to network communication failures. Therefore, it is vital to minimize the occurrence of missed requests and optimize the sleep time to ensure efficient and reliable communication.

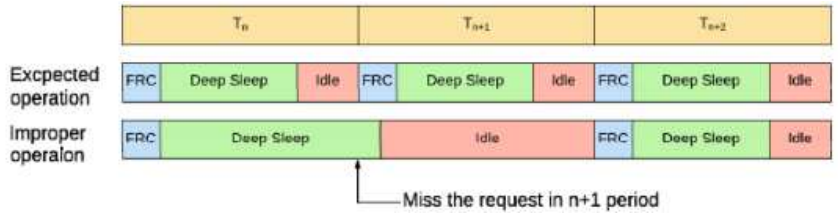

Figure 5
Expected and improper operation of deep sleep mode

To ensure that all sensor nodes are in the idle state before the next request is transmitted from the network coordinator, it is necessary to calculate a deep sleep time that is shorter than the period time. This is because all nodes must be in the idle state before the request is sent.

The deep sleep time calculation is based on the worst-case wake-up times of the sensor nodes. To determine the deep sleep time, we measured the sleep time and identified the maximum differences between the wake-up times of the nodes. We then used these maximum values to fit a linear regression, as shown in Figure 5. Using this regression, we can calculate the deep sleep time of the sensor nodes in seconds, as follows:

$$t_{dsleep} = (t_{period} - t_{FRC}) - 0.00219 \cdot (t_{period} - t_{FRC}) + 2.70629 \tag{6}$$

where t_{period} is the time until the next data collecting period and t_{FRC} is the duration of the data collecting communication. To ensure proper synchronization using the deep sleep method, it is important to calculate the inaccuracy of the internal clock of the radio modules.

Idle Mode

The IQRF technology incorporates a method known as Low Power Receive (LP-RX) mode, which aims to minimize power consumption by periodically disabling the receive mode and shutting down the transceiver module. Specifically, the LP-RX mode defines a period of 47 milliseconds for IQRF devices, during which the radio module attempts to detect incoming RF packets.

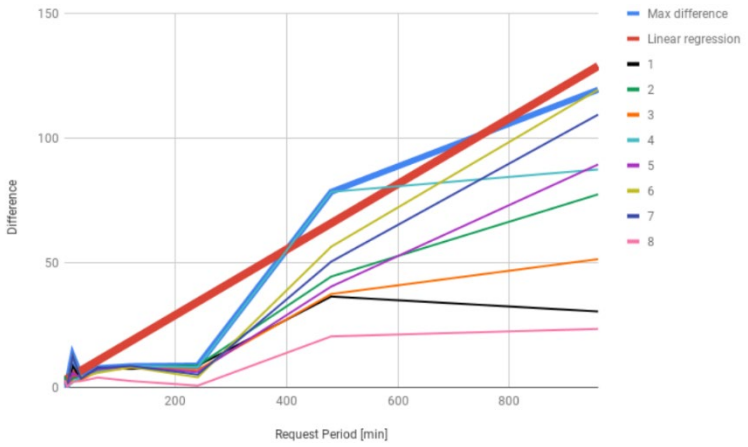

Figure 6
Expected and improper operation of deep sleep mode of IQRF modules

To signal the start of a packet, the sender node transmits a 50-millisecond long preamble that can be detected by the receiver nodes. Once the preamble is detected, the receiver stays in receiver mode to receive the rest of the network packet. Compared to the standard receiving mode, the LP idle mode power consumption in a noise-free RF environment is only about two percent, which can lead to significant energy savings for battery-powered devices.

However, even in LP-RX mode, the RF circuitry may still consume some power due to synchronization needs or other factors. Therefore, the use of synchronized deep sleep mode can further reduce the energy consumption of the sensor nodes, especially in cases where the request periods are longer. In contrast, the normal RF receive mode keeps the RF circuitry on all the time, which can lead to higher energy consumption and shorter battery life. Overall, the LP-RX mode is a useful feature of IQRF technology that enables efficient and reliable communication while minimizing power usage [15] [16].

In the test nodes, the IQRF RF modules utilize a watchdog timer in conjunction with a low power oscillator to control the timing of the deep sleep mode. This timer covers a wide range of sleep intervals, allowing IQRF to define the deep sleep quantum as tqsleep=2.097 s, which is based on the properties of the microcontroller being used [13]. During this deep sleep mode, the device is in an idle state and is able to conserve power by shutting down non-essential functions. The duration of the idle state can vary based on the specific application and usage scenario:

$$t_{idle} = t_{period} - t_{FRC} - \lfloor t_{dsleep} / t_{qsleep} \rfloor \cdot t_{qsleep} \tag{7}$$

where t_{dsleep} is the deep sleep time of the sensor nodes taking into account oscillator inaccuracies. The energy consumption of the idle state can be

determined using the average current for low power (LP) mode, represented by ILP, as follows:

$$E_{idle} = UI_{LP}t_{idle} \tag{8}$$

where I_{LP} is the average current for LP mode by IQRF.

Request Broadcast Message Routing

The FRC (Fast Response Communication) method begins with a request broadcast message, which is sent out to all nodes in the network. Each node then repeats the packet in their own designated time slot and subsequently disables their transceiver module, as they do not need to receive any more packets until the end of the routing process. By repeating the packet in this way, each node in the network is able to receive the message, ensuring that it is delivered to all intended recipients. This approach can be an efficient way to quickly disseminate information throughout a network, as it allows for the simultaneous transmission of data to multiple nodes without requiring individual requests or acknowledgments. Overall, the FRC method is a useful tool for enabling fast and reliable communication within a network. The energy requirement of the request phase is:

$$E_{request} = U(I_{Rx}(t_p + t_{req}) + (N-2)\cdot I_{idle}(t_p + t_{req}) + I_{Tx}(t_p + t_{req})) \tag{9}$$

Processing

Once the request message is received by all network nodes, they begin processing the acquired sensor data and preparing it for collection. In the test network, the sensor nodes utilize a low-power digital temperature sensor which consumes less energy than the idle mode energy consumption of the RF circuits. This helps conserve energy while ensuring efficient data collection. The energy requirement of the request phase is:

$$E_{proc} = U(I_{idle}t_{proc}) + E_{sensor} \tag{10}$$

Non-Routing Beacon Packets

During the upcoming phase of the FRC, each node will transmit its sensor data to neighboring nodes during designated time slots. To receive data from all neighbors, each node must remain in receive mode until all other nodes have transmitted their packets. Once the packets are received, the nodes will merge the payload data based on their respective network addresses and include their own measured values. The energy consumption of the beacon phase is:

$$E_{beacon} = U(I_{Rx}(N-1)t_{bc} + I_{Tx}t_{bc} + I_{idle}t_{bcw}) \tag{11}$$

To ensure proper communication, each node must remain in receive mode for N-1 time slots to receive data from other nodes, and then one additional time slot to

transmit data to its neighbors. Following the beacon phase, the nodes will wait a short t_{bcw} time slot before proceeding with data transmission.

Response Message Routing

The response message routing phase begins with the node having the highest VRN number transmitting the merged payload. The network nodes will then route the response message payload towards the data concentrator by repeating it in decreasing order of VRN numbers. Each node will merge the payloads before routing the packet. As a result, when the data concentrator receives the last packet and merges it, all measured data from all sensor nodes can be found at the appropriate location within the response message payload. The energy consumption associated with the beacon response message routing process is:

$$E_{response} = U(I_{Rx} t_{resp}(N-1) + I_{Tx} t_{resp}) \tag{12}$$

To receive incoming messages, nodes must remain in receive mode for N-1 time slots, as is the case during the beacon phase. After receiving messages, nodes need to transmit their own message in a single time slot.

4 Estimated Battery Life of the Sensor Nodes

The lifetime of the network is determined by the first node that becomes unable to communicate [28] [32] [34]. Typically, the network's lifetime is defined as the moment when the first sensor becomes inoperable due to low battery. This is a commonly accepted definition of network lifetime.

To estimate the battery lifetime of a sensor node based on its energy consumption, the following steps can be taken:

- Calculate the total energy consumption (E_{total}) of the node by using a suitable model and determining the average current to define the appropriate discharge characteristic of the battery.
- Determine the maximum number of data collecting cycles that can be served from the battery capacity, using the proper battery discharge characteristic.
- Calculate the estimated battery lifetime from the maximum number of data collecting cycles and request period.

The total energy consumption of the node depends on several factors, including the number of nodes in the network, data collecting period, and the number of data collecting requests in each period.

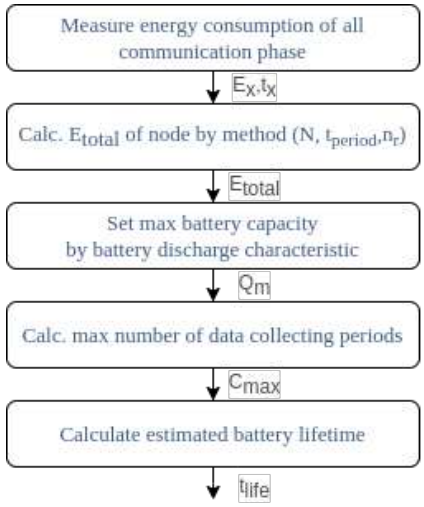

Figure 7
The total energy consumption (E_{total}) of a node for one data request per period

Figure 8, illustrates the total energy consumption of a sensor node in the case of one data request per period, based on the parameters of the TR-76D module [16].

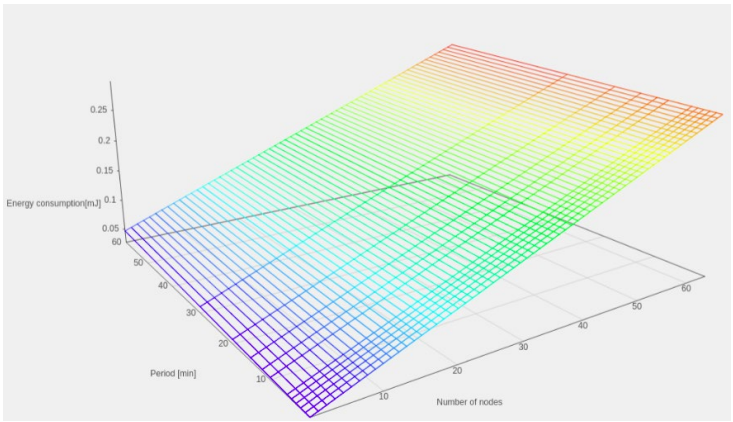

Figure 8
The total energy consumption (E_{total}) of a node for one data request per period

To estimate the battery lifetime, we need to determine the maximum number of data collecting cycles that can be supported by the battery's capacity. While lithium thionyl chloride ($Li/SOCl_2$) batteries have high capacity, high energy density, and low self-discharge rates, their output current capability is limited. Additionally, the battery's capacity varies significantly depending on the discharge rate. Despite these limitations, $Li/SOCl_2$ batteries are still an ideal choice for long-term running applications [30].

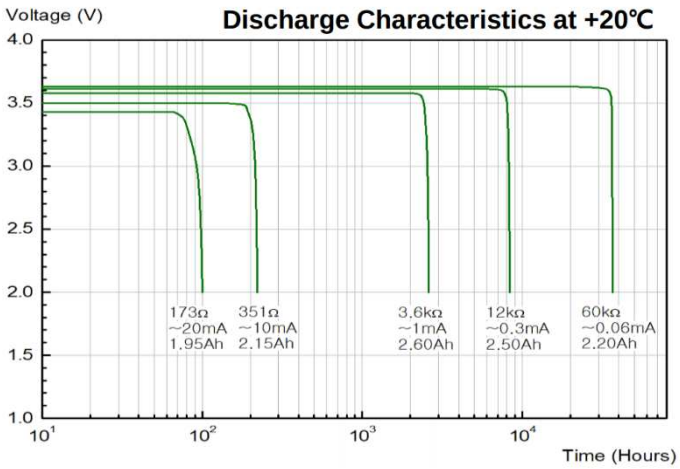

Figure 9
Discharge characteristic of Li/$SOCI_2$ battery [26]

The capacity of a battery depends on the average energy consumption and can be determined by analyzing the battery's discharge characteristics while considering its maximum pulse current capability. Figure 9 illustrates the discharge characteristics of a Li/$SOCl_2$ battery at different loads. Additionally, the battery's self-discharge characteristics are affected by the load and can impact its expected lifetime. After 10 years of discharging to 90% of its nominal capacity, a Li/SOCl2 battery typically retains a capacity that reflects its discharge characteristics. Notably, the self-discharge rate of a Li/$SOCl_2$ battery is extremely low, less than 1% per year at 20℃, which enables long storage periods and a service life of 10 to 20 years[29].

One of the primary challenges with this type of battery is that when it comes into contact with SOCl2, the lithium rapidly reacts to form a passivization layer that can slow down further corrosion reactions. This affects the battery's lifetime, which depends on various factors, including the storage time and environmental conditions between manufacturing and the battery's use in sensors. Due to the complexity of the factors that influence the Li/$SOCl_2$ battery's self-discharge rate, it is challenging to establish an accurate mathematical life prediction model for this type of battery[30]. Despite these challenges, the maximum number of data collection cycles that can be supported by the battery's capacity during its' lifetime is:

$$C_{\max} = \left\lfloor \frac{Q_m U}{E_{total}} \right\rfloor \tag{13}$$

where Q_m represents the battery's capacity, which is determined based on the discharge characteristics at the end of the battery's life.

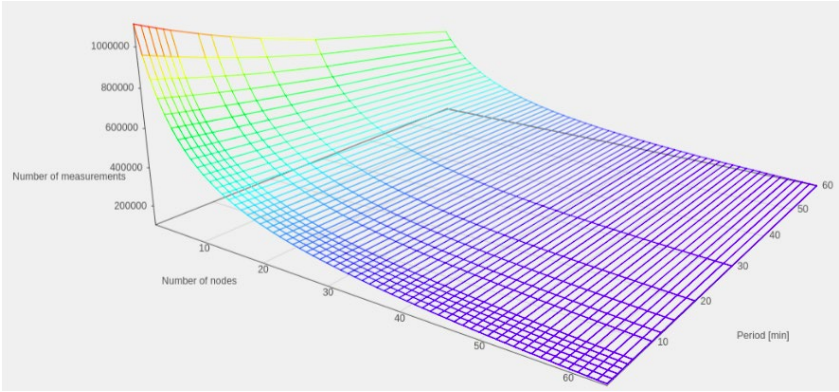

Figure 10
Maximum number of data collecting cycles that can be served from the battery capacity

Figure 10 illustrates the nominal battery capacity, which can be used to determine the maximum number of data collection cycles that the battery can support. By calculating the maximum number of data collection cycles, we can estimate the battery's lifetime:

$$t_{life} = c_{max} t_{period} \tag{14}$$

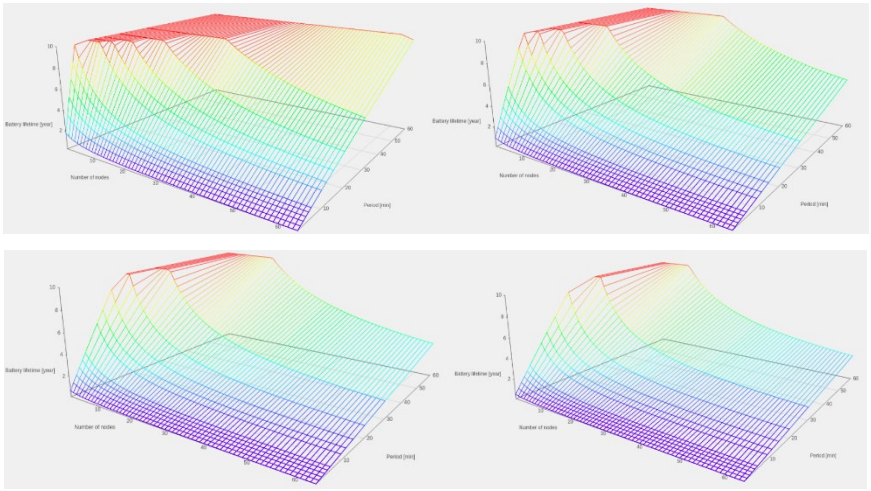

Figure 11
Estimated battery lifetime at up to 4 request per cycle

Based on the parameters of the TR-76D module, Figure 11 depicts the estimated battery lifetime for up to four requests per data collection cycle and a maximum lifetime of 10 years. The diagrams demonstrate that increasing the number of nodes in the network or collecting data more frequently can significantly reduce

the battery's lifetime. However, increasing the number of nodes in the network can be offset by decreasing the data collection interval.

To validate the model, we conducted short-term testing using a test sensor network. Additionally, we initiated a long-term test using six sensor nodes, which will span over five years. However, the long-term test may yield different results due to the $Li/SOCl_2$ battery's capacity characteristics. In the test sensor network used for model validation during short-term testing, we employed:

- 3 sensor nodes (IQ Home SI-T-02) [27]
- XL-060F batteries from the same batch [26]
- 1 minute data collecting period with 2 requests per period (temperature + status)
- Estimated battery life by the model: 207 days

As previously defined, the lifetime of the sensor network is determined by the first inoperable sensor node. However, in our test networks, we wanted to observe the battery life of all sensor nodes, not just the first one to fail. To achieve this, we set up the sensor network with each sensor node having a direct link to the coordinator. This design ensures that network communication is not interrupted in the event of any node ceasing to function. By observing the battery life of all sensor nodes in the network, we can gain a more comprehensive understanding of the overall performance and durability of the sensor network.

Figure 12
Temperature values until the end of battery life in short-term test network

Figure 12 shows the temperature values collected during the short-term test network. The test lasted 245 days until the last sensor node's battery became low. Table 2 presents the results of the battery life test. The primary objective was to validate the estimated battery life of each sensor node, and each node worked until the estimated time. However, the significant difference between the results can be attributed to the $Li/SOCl_2$ batteries used, even though they were from the same

batch and order, and stored under similar conditions. This variance emphasizes the importance of testing and validating battery life to ensure accurate and reliable sensor network performance.

Table 2
Results of the short-term battery life estimation test

Node	Estimated battery life (days)	Battery life (days)	Error
1(green)	207	216	+4.35%
2(red)	207	208	+0.48%
3(grey)	207	245	+18.36%

5 Energy Consumption Distribution in the Network

The energy consumption distribution of a wireless network depends on the specific architecture and data collection methods employed [29-32]. Assuming a homogeneous network with identical sensor and battery types, variations in energy consumption can be attributed solely to the communication costs of the data collection method. Therefore, it is crucial to understand the energy consumption distribution as it directly impacts the network's lifetime. Any node with higher communication energy costs than the others may become inoperable sooner, potentially causing communication issues. This is because the network's lifetime is determined by the first node that becomes inoperable.

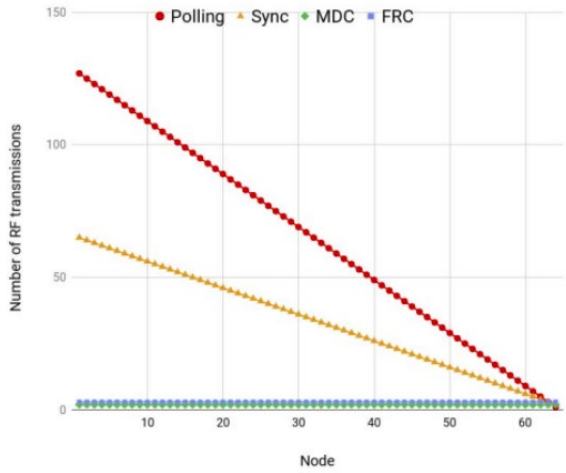

Figure 13
The distribution of number of transmissions at different data collecting methods in a 64-node network

In TDMA wireless mesh sensor networks that utilize flooding routing, the merged data collection (MDC) method results in uniform communication energy costs across all nodes, regardless of their location in the network. This is because routing nodes must transmit messages to the same number of nodes, regardless of their location, when using MDC methods. Figure 13 illustrates the number of transmissions required by different data collection methods in a network with 64 nodes. The energy consumption model of sensor nodes using MDC methods depends only on the total number of nodes in the network, and not on their location.

Conclusions

This paper presents an energy consumption estimation method, for sensor nodes in TDMA wireless mesh sensor networks, that utilize FRC merged data collecting methods and lithium thionyl chloride batteries. We describe a battery life estimation method, which we validated through short-term testing using a test sensor network. The battery life of a sensor node in a homogeneous network depends on three factors: the number of nodes in the network, the data collection period, and the number of data collection requests in each period. By decreasing the data collection interval, the battery life estimation method can compensate for the increasing number of nodes in the network. We also demonstrate that the communication energy cost of nodes using merged data collecting methods in TDMA wireless mesh sensor networks, based on flooding routing, is uniform across all nodes, regardless of their location within the network.

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The Success of Online Education from University Students Perspective

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Abstract: The changes of recent decades in the context of the rapid development of technology also necessitate the transformation of the learning environment and digital changes. This switch, as a result of Covid19, has meant a sudden move from so-called "digital education" worldwide overnight, affecting the structural, planning and implementation process alike. In order to achieve successful learning, it is necessary to monitor the effects on students and instructors, and to look back on online education with the success of the next school year in mind. One side of this is the student side, the experiences and feedback, the importance of which is now even more appreciated. The research is looking for an answer to how the students experienced the unusual, completely online learning, what their opinion is about the solutions provided by the university and the lecturers, how they evaluate the role and preparation of their teachers. The main question is how much they consider purely online lessons, lectures to be a big challenge, what they think is successful and why, how they see the role of their teachers. The implementation of methodological solutions and variety is also a question. Knowing the results, based on student opinions and own experiences, the study formulates suggestions for increasing future efficiency not only for Covid19 or similar periods, but for digital and online education in general and for the longterm.

Keywords: online and digital education; teacher and learner-centered methods; auto-etnography; teacher's role/attitude

1 Introduction

1.1 Basic Concepts

First of all, it is advisable to clarify the related basic concepts.

- Distance education: "Distance education is a form of training based on guided independent learning that replaces the regular personal contact between the instructor and the student for most of the learning time with

various learning tools (distance education textbook, guides, multimedia learning materials, etc.)." [1] The training time is divided, mostly self-study, but the student participates in the consultations. The teacher takes on a helping and supporting role, which is not a negligible motivational and success factor, that is, the success of learning also depends on the teacher's attitude. The training time is shared, mostly self-study, but the student participates in the consultations. The teacher is helpful and supportive, i.e. the success of learning also depends on the teacher's attitude.

- Digital-based learning: self-learning activity takes place, for which some kind of computing device is used. The source of learning can be a multimedia tool, simulation, interactive task.
- eLearning: independent learning takes place in the form of training based on a web-based IT network. In a broader sense, this includes all training that uses some kind of IT tool to support learning. The teacher and the students communicate electronically, typically there is no personal teaching.
- Blended learning: similar to eLearning, but in practice there is an example of personal consultation taking place at most a few times according to the student's needs, requests or the teacher's determination.
- mLearning: learning using mobile devices. Knowledge or starting sources for learning are uploaded to the devices with the help of various applications. It is actually a mobile device extension of eLearning.
- Digital learning or digital distance learning: a simplified form of the previous ones realized in distance learning, online. Multimedia devices, electronic educational packages, nowadays several cloud services can be connected to it, the access is wider, from anywhere, even from mobile devices, via telephone. [2]
- Online education: implementation of virtual and Internet-based education, application of several technological solutions - computer, smartphone, virtual classroom, use of digital collaborations. [3]

It deserves a special mention that digital and online education appear as synonyms for each other and in some cases under the name of digital pedagogy, as György Molnár calls it, and perhaps this term sums up the complex interpretation approach most relevantly. [4]

1.2 The Online Education in Hungarian Education

In Hungary, digital education was introduced overnight (from Thursday evening to Monday morning), first in primary and secondary schools. The transformation of public education into distance education caught Hungarian teachers unexpectedly and unprepared, just like their colleagues around the world. Until the

spring of 2020, distance learning was primarily more important in higher education and vocational training, but the majority of teachers working there also faced a serious challenge. Even the more experienced ICT users had to deal with the change brought about by the different learning environment, different teaching conditions, different learning and teaching tools and methods, and especially with the need to teach differently. It was questionable whether the proven and successful methods in full-time education will also work in distance education and if so, how, not to mention the teacher-student relationship, while the participants are the same. A Dutch research recalls a similar situation, according to which the 8-week school closure in the spring has such a harmful consequence, which is similar in strength, as if the students were almost completely absent from education. [5]

Another complicating factor is the lack of time, not to mention the fact that school activities and the learning-teaching workflow cannot be transferred exactly one-to-one to the digital work schedule. However, the circumstances forced the participants of the education to do so, which essentially resulted in the fact that online education did not actually take place (at least for a while), rather we can discuss Internet-supported individual learning at home.

For at least partial realization, an opening and a turning towards the teachers is necessary, i.e. the role of attitude is decisive. The OECD PISA research results show that digital education is not only a matter of material and asset conditions, but requires preparation, knowledge, and skills on the part of both students and teachers. [6, 7]

According to the author's field observations, one of the many examples of solutions was the involvement of public workers in several settlements, in other cases the teachers or pedagogical assistants themselves organized and took the packages and weekly worksheets compiled by class and subject to the cultural community places of the settlement (cultural center, etc.).

1.3 The Online Education in Higher Education

Higher education has a little more time, one week left for the transition to online education. Similar difficulties occurred here as well, mainly among students studying in the correspondence work schedule, but the majority of the problems were of a different nature. Rather, it is of a methodological and personal nature, and the first difficulty is that the students had to use several platforms, since there was not always a uniformly defined platform within the training within an educational institution, or time to quickly coordinate the platforms. [8]

Higher education generally continued to use the existing and previously problematic Learning Management System (LMS) infrastructure. With the help of applications, they mainly made video conferences possible, following the classic educational style. However, the limits of the systems prevented optimal operation,

the necessary conditions for education were incompletely realized. "As a result, fully integrated systems and their associated methodology could not be created, although new combinations of existing solutions undoubtedly created new opportunities." [8]

The digital model was therefore able to be realized in the sense that the learning and teaching activities were carried out relying on the Internet and online interface, optimally with the help of software applications available to everyone. Planning and implementation and the meeting and relationship between students and instructors have been transferred to a digital space, where the boundaries of the university classroom and subjectivity, the home, have been placed in the same space. New status, new positions were created, new points of identification, interactions and solutions had to be found on a different communication channel. The cultural software phenomenon formulated by Balkin, which interprets social processes and communication between people in an unusual but feasible space, seems to be coming to filfilled and fruition. [9]

In this approach, we can interpret it so that the individuals participating in online education are present as "cultural software" and in this social and communication environment they convey cultural information, knowledge, and opinions to each other. Thus there will be value boundaries, disagreements and agreements. The author believes that this is also a new space and opportunity for cultural diversity and joint learning and cooperation. Although Barkin mentions the problems of understanding different views as the remnants of older problems, in the author's practice the possibility of moving in the direction of positive change is more prominent.

1.4 The Online Education at Óbuda University

The digital form of education was not new at University of Óbuda, as a technical university, programs were already used on various interfaces. The use of Neptun is basically in the subject and student register and it is the evaluation interface, and the Moodle framework is the place to complete course materials, instructor presentations and assignments. What has changed in the newly created situation is the platform for communication with students, which has been moved from the largely face-to-face education to the Microsoft TEAMS interface. In the beginning, this was not uniform, several people did not keep their lessons, lectures, others try to continue teaching on different platforms, such as skype, discord, or - like myself at the request of students - they recorded it with repeat students via Zoom. Later, Moodle's Big Blue Button was also added to the options. The university leaders had to make quick decisions. The communication interface was also unified, and ensuring continuity required the patience and quick action of both the instructors and the IT staff.

In general, we can state that a very close cooperation was formed in order to maintain education, and it is thanks to this that the transition to digital distance education was able to be realized in a few days - following the immediate actions of the rector and dean, deadlines and the quick response of the instructors. So the launch was successful. The first problem was that the necessary tools for the realization of digital education were not available everywhere, neither on the teacher's side nor on the student's side. The university also had to solve this, which sometimes did not go smoothly. An example can be mentioned asking the teachers about the necessary tools, which they could not provide quickly in all cases, as this certainly has an economic and organizational side.

The preparation took place in the following steps:

- Selection of a suitable educational platform, which at first could be freely chosen by the lecturers, but recommendations were sent, and there was also a platform chosen based on student suggestions.
- According to the central trend and the rector's instructions, the use of specific platforms has become institutionally defined in a uniform manner.
- The provision of digital tools for teachers has started, the needs and tools already available from all teachers have been collected.
- Preparation of written and video information for the use of the software centrally, with the involvement of the IT staff.
- Organization of webinars to prepare the use of different platforms. This was particularly useful for the majority, but many found it difficult to engage or there was too much information to learn at once. It was easier to use with the written instructions.
- Preparation of a digital education plan in a uniform template - in the form of central and individual instructors.
- Preparation of digital curriculum schedules by teachers in a few days.
- Elaboration of assessment forms by the teachers broken down by subject and writing precise instructions and information for them in a few days.
- Preparation of digital teaching materials, revision of previous teaching materials or elaboration of new ones.
- Start of online education at the times according to the original timetable: creation of TEAMS groups, notifications, information to students and access to the given course group.
- Holding online lessons and lectures, closing the semester and exam results, mid-semester grades.

In the first days, due to the increased load, testing of educational platforms began. Information exchange between students and instructors began, groups were formed and the sharing of knowledge developed rapidly, and the groups and study

material banks of each subject became available. The use of the platforms was assisted by the technical and IT support with descriptions and videos, and the students presented these with the help of each other and, if necessary, the instructor. Not only the teachers participated in the creation of the study material banks, they also asked for and received help in many cases.

The semester started and continued, and the next academic year continued in a similar way, remaining online, including school practices. Our pedagogical practice, led by the author, was strongly developed for face-to-face education, and due to lack of time, we did not prepare the rethought, reworked concept for distance education beforehand. The new 1st-semester students starting their pedagogic practice and the university instructor-practitioner, as well as the relevant school departments and their teaching colleagues, were far away from each other in space and time. The primary purpose of the professional practice at school is to establish the professional development of the candidate teacher, the first encounter with one's own role as a teacher. A particularly important goal is to develop competencies that contribute to becoming a teacher and to awareness of one's own identity as a teacher. Without real situations, students, and a real school, this task becomes almost elusive, so it is not an easy task as a university instructor to help them experience the complexity of teacher roles.

As a teacher of pedagogic subjects and as a teacher in practice, I myself also had difficulties with the transfer to the online space. As support and encouragement, I brought forward the relevant parts of certain pedagogical subjects (e.g. didactics), as well as additional knowledge not included in the curriculum, and I made concessions regarding the number of hours of participation and the duration and content of the individual lessons. The exercises were successful, the initial difficulties were replaced by trust and a common exchange of opinions, which the students later thanked in separate letters. This way my idea of online cultural diversity and learning together/from each other has worked.

2 The Research

2.1 Objectives

The problem is currently one of the most important issues in education, so all information and experience can be useful and forward-looking. The research seeks an answer to how the teacher candidates experienced online distance learning, what difficulties they had to face, what help they received, and what they lack in order to successfully complete the requirements and exams.

The main question is how much of a challenge the participants, instructors and students consider digital tools and purely online classes to be, what they think are advantages and disadvantages, what they consider successful and why. It is also a question of the training and digital competences of the instructors, the methods used, their effectiveness and popularity. The research affects the support provided/received in online education, the amount and difficulty of the tasks, as well as in which areas more support is needed. The research seeks answers and formulates proposals for increasing efficiency in the future, not only for the duration of Covid-19, but also for the long-term.

2.2 Hypotheses

1) Thanks to their digital competence, the engineers, engineering and technical teacher students were easily involved in online education.
2) The digital competences of teachers/lecturers were weaker than students.
3) The methods used by instructors are teacher-centered, primarily based on presentation and explanation, and are less interactive.
4) The evaluation method is primarily quantitative and summative.
5) Students in online education received less support and more tasks than in face-to-face education and the learning experience was not as strong and effective as classroom education.

2.3 The Circumstances of the Research and the Informants

The research begins in the 2019/20 academic year and continues in the 2020/21 academic year. The participants are students of various years of Óbuda University Kandó Kálmán Faculty of Electrical Engineering, Ágoston Trefort Center for Engineering Education engineering, engineering teacher and technical teacher training, as well as engineering students not participating in teacher training, who choose pedagogy subjects as optional subjects to fulfill their mandatory credits . Some of the students started their studies before Covid in the context of face-to-face education, but continued and completed them online, in the current semester or, in many cases, later. It is a relatively small population that had to cope with situations such as teaching practice or learning optional subjects, without any significant prior knowledge and practice. Data collection was done quantitatively and qualitatively. The questionnaire intended for students was filled out by 324 respondents. The majority of students take part in correspondence courses; several already have teaching experience. However, another part of the students have no teaching experience, are beginners in the teaching profession, or have not yet decided definitively to become a teacher in addition to the engineering career. However, they may have important professional experience in other fields, such as IT.

The average age of the interviewed students is 37.93 years. 64.7% of the respondents are already practicing teachers, and 57% of the entire sample works in vocational training. Despite the fact that the average age of the respondents is almost 40 years (and most of them belong to the 40-49 age group), 26.6% have one year of teaching experience or less, and 39.7% have taught for up to 5 years. (Table 1)

Table 1
Student's educational experiences

Years of teaching experience	Respondents (%)
0	26,6
1-5	39,7
6-10	20,1
11-15	4,4
16-20	2,3
21-25	1,8
26-30	5,1

Most of the students therefore have little pedagogical knowledge, they see education from the student's point of view, but there are colleagues who have been working at the school for a long time. In the latter case, the majority is from an older age group, generally the younger ones The questions, conclusions, and suggestions formulated here can be useful in general and for specific cases, or for a national survey, but also for the analysis of educational platforms. The research is currently continuing by interviewing several students, planning to involve other institutions. In this study, we highlight the results that affect the practice of university education and contribute to practical teacher training.

2.4 The Quantitative Research Side

The fastest way to approach students was to ask the own groups opinion. I used a self-edited Google Forms questionnaire due to ease of availability and filling. In a small group, mainly studying computer science, the students completed a trial test, commented on the questionnaire, which was then distributed, in which the students also helped (forwarding, sharing on Facebook, etc.). This method seemed to be faster than contacting teaching colleagues through the university, and thus we can expect to get a layer that is perhaps smaller in number, but more reliable in its answers, which provides the sample.

The questionnaire is divided into several units. Most of the questions are one-question measurement scales ranging from 1-5 or 1-4 between the two extreme values. After the demographic data, the first part asks about the rate and method of participation in online education: keeping classes, digital teaching materials,

assignments. The second part of the questionnaire focuses on the student-teacher relationship: the forms, frequency and quality of contact, what the teachers could (or couldn't) help with due to the peculiarities of distance learning. In the third part, you can talk about general experiences, looking for answers to how the students experienced learning, school pedagogical practice, in which areas they felt successful, and in what they experienced failure. There is also the opportunity to answer open-ended questions, which is justified due to the extraordinary nature of completely online learning. It seems that the subjective "data" is telling and it is important to supplement the objective data with these, it is necessary and worthwhile to find out about the subjective feelings of the students in all situations, but especially in extraordinary situations. Some of the results of this are also mentioned.

2.5 The Qualitative Research Side

The qualitative side of the data collection is observation, continuous communication with the students, and the use of the auto-ethnography method combined with reflections on mobile phones or other platforms, forums. The specific method of cultural anthropology, the experience of participant observation, provided the qualitative basis, which I practiced several times during fieldwork in Africa. Its relevance here is that it helps create the crossing of distance frames and the realization of seeing from the other side. An important aspect here is what kind of relationships you can establish with the members of a particular community coming from outside. In this case, this community is the student group. [10, 11]

The novelty of auto-ethnography lies in the fact that it views all research as having a biographical nature (from a methodological point of view), on the other hand, its peculiarity is that the researcher can involve others through his own feelings, experiences, and stories, and make others speak and, more broadly, to find systemic connections. [12] The method also helps to reflect on one's own role, it is like analyzing an intersubjective communication situation. In light of this, it becomes easier to change the activity, the processing method, continue and change tasks and explanations during education. Thinking about the success of the method experienced in the previous face-to-face classes, I also applied it during the online education and shared my own thoughts and experiences to inspire the students to make observations. This is how I managed to encourage them to consciously observe their own experiences and learning. According to all of this, I interpret the online education space as a cultural evolution, in the lessons held in TEAMS groups, using the forum, chat and curriculum placement and assignment functions provided by Moodle. I developed the concept of a new space for cultural diversity and joint learning and cooperation, which includes the further development of social skills and soft skill elements. Based on this, I planned, organized and coordinated my university lectures and classes and formed the relationship with the students.

3 Results

3.1 The Digital Competences of Students and Teachers

ICT knowledge, material conditions, and internet access show a changing picture, which can partly affect the success of online learning. However, only a small proportion of the students have poor IT skills, the majority are at least well or definitely familiar with the use of digital opportunities. (Figure 1)

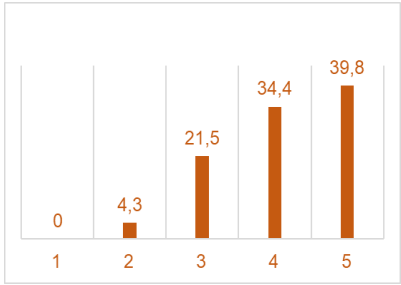

Figure 1
Student's IT proficiency

Most of the students are familiar with one or two or more forms of digital learning. Mostly e-learning courses. Previously, and during online education, they used the e-learning system often weekly (45.2%), but at least monthly (32.3%), and according to their statements, they learned from the slides and presentation materials prepared by the teachers in addition to completing extra tasks. Hypothesis 1. was thus proven to be realistic. (Figure 2)

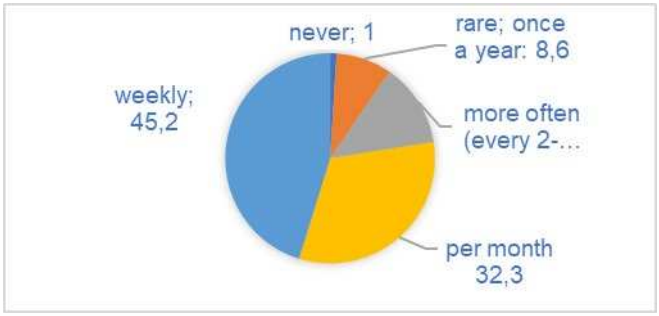

Figure 2
Frequency of e-learning earlier

Another indicator of satisfaction is the general digital preparedness and communication of the lecturer-teachers. The majority of students, 89%, thought this weak, and only a few percent marked it as good or excellent. The almost

unanimous opinion may be related to the results collected in a qualitative way, that some of the instructors did not keep all their lessons and at the beginning of the attendance education, they did not inform the students about how they would continue learning, on what platforms, when the lectures would be held, or incomplete was the communication and the given information. (Figure 3)

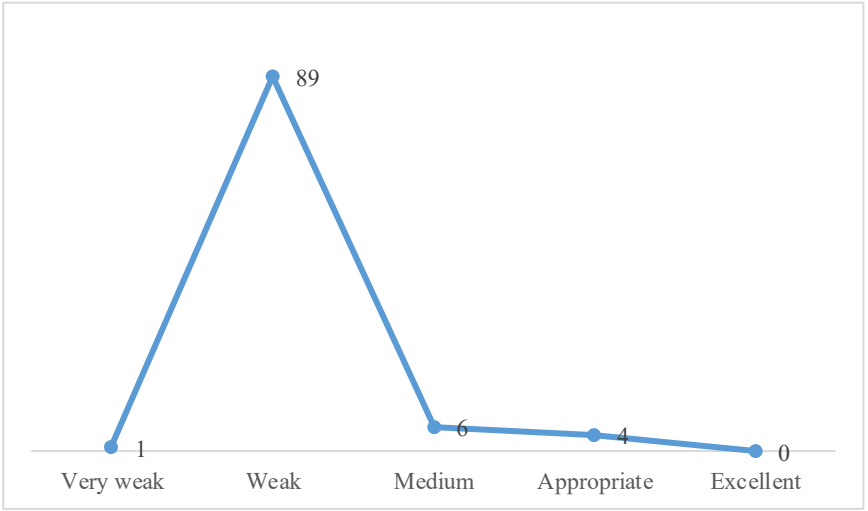

Figure 3
Digital preparedness and communication of teachers-lecturers

67% of students are not satisfied with the availability of instructors and the quantity and quality of contact and communication with students. They believe that the instructors are not helpful and attentive enough, they just give their lectures and expect the students to prepare alone even in the more difficult subjects. Thus, Hypothesis 2. was also confirmed.

3.2 Evaluation of Online Semesters Generaly

A significant number of students do not think the quality of online education is adequate overall, and consider it worse than face-to-face education. On a scale of 1-5, where 1 is the worst, 54.5% would give a 2 rating, 15.7% a 3, while only 5.3 would give a 4 on a 5-point scale. (Figure 4)

Expressed in one word, the feelings related to online education partially reflect the previous, 13 out of 24 statements refer to a negative opinion, but we see a slightly more nuanced picture on this issue during the qualitative research. (Figure 5 Word cloud)

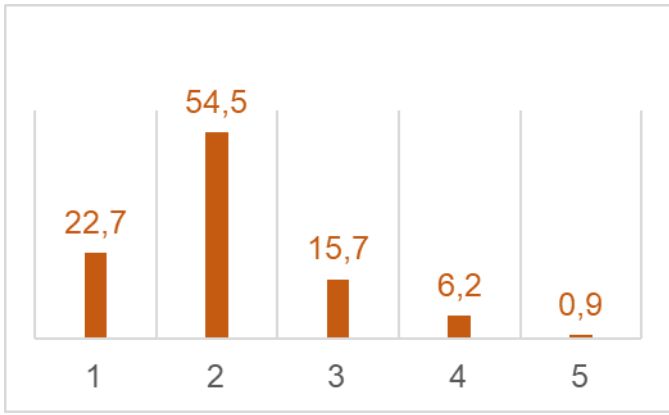

Figure 4
Evaluating the online education

Figure 5
Evaluating the online education using auto-ethnography

During the autoethnographic conversation, the students formulated and wrote down in a word cloud the words that express their emotions and opinions using association exercises and reflection surfaces. We created a group word cloud from the phrases that occur most often in each word cloud. Figure 5 summarizes this. Another indicator of satisfaction with education and instructors is the availability of instructors and contact and communication with students. 67% of the students are not satisfied, many consider the biggest shortcoming to be that the contact was limited to the availability of the course material and the keeping of classes.

3.3 Teaching Methods, Evaluation and the Involvement and Activity of Students

The involvement of students is one of the biggest challenges, and it is determined by the role and attitude of both participants. For the majority of the students, the learning experience is that the lecturers did not know or did not strive two-way communication, and those teachers who did the same during attendance teaching were able to mobilize them.

Of course, there may be a lack of tools in the background, but the qualitative research shows that many students felt this new way of interactivity in communicating with the teacher to be unusual and sometimes unpleasant. Several people expressed that it was uncomfortable to speak in front of the group and they were especially frustrated that the lessons were mostly audio and video recorded. For those who find it difficult to communicate two-way anyway, their frustration increased even more, because the personal absence and influence of the teacher and peers gave more room for uncertainty. The teacher's tone and communication were mentioned several times. One of the students described the general feelings of loneliness and frustration as follows: "We are left to our own devices and we are expected to learn things that the teacher tells us in advance that 80% of the group will fail. We don't even get a word of encouragement, they don't even know who I am, what I'm like, they don't believe that I'm learning a lot. Here, in this class, I like to get involved because here I am not just a Neptun code."

The research results show that the variety of teaching methods has decreased, and teachers have been less creative. The instructors preferred to stick to traditional, face-to-face teaching methods in the digital space, even during online education. They preferred the most classical methods, by which they were probably educated themselves, and which are most prevalent in university education. Only a few used the new type of methods, which better induce student activity, both during the face-to-face and online semesters. (Fig. 6)

Teaching methods and solutions have decreased, and students encounter one-sided teacher-centered, lecture-based methods in almost every class. Lecturers gave presentations most often, and the preferred method was explanation, which was known and encountered during distance education in almost 100% of cases. Common methods include illustration, which the students said in the qualitative research was part of the presentations in most cases. The next is the individual work, which mainly means homework and various assignments to be submitted by deadlines, readings, and home processing of a part of the curriculum.

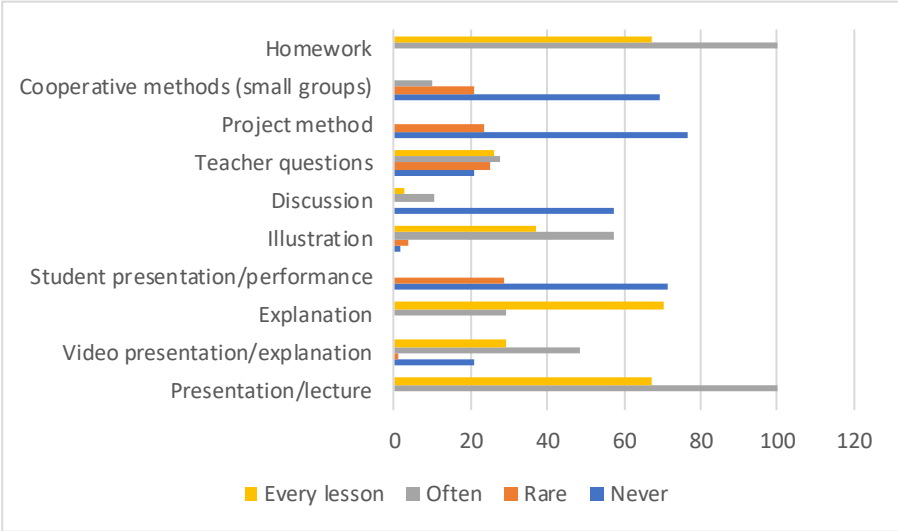

Figure 6
Frequency of use of certain teaching methods

Project tasks supporting the students' joint work took place the least, cooperative learning in small groups were encountered only in a negligible proportion. With the help of qualitative methods, it turns out that there are examples of the use of interactive methods in a few subjects and even fewer instructors, practically the same teachers use the same methods continuously. It becomes clear that the majority of respondents are dissatisfied with the teacher's one-sided communication and miss exploratory-discovery, research-based learning.

The students also relate the learning atmosphere to this, they express that it was difficult to keep their attention during the several hours of online lectures, they felt even more monotonous than classroom lectures. The majority of teachers did not try to involve them in their own learning and did not ensure more active participation. In their opinion, this is a lack of preparation and a question of determination, which should be changed. Hypothesis 3, supported by these results, was also confirmed.

From the point of view of the evaluation, it is worth noting that online testing is perceived as better than an exam, but in many cases they think the time frame given is insufficient and feedback is missing. Related to this, according to 87% of the respondents, the vast majority of evaluation methods are one-sided and summative, meaning that even with the online background, the traditional classification and numerical evaluation form remained. Other forms of evaluation occur only in the case of some instructors. (Figure 7)

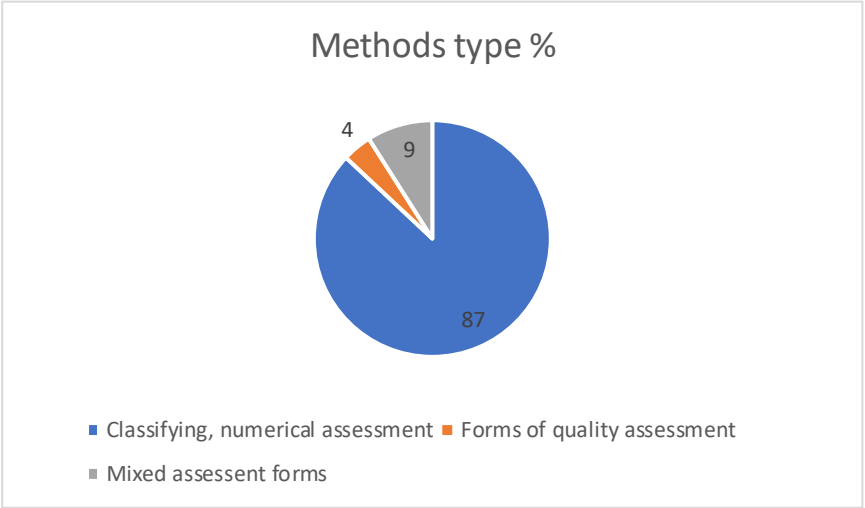

Figure 7
Proportions of assessment method types

Forms of classification and numerical evaluation were point-percentage tests and tasks, similar type of closed-door papers with closed questions, and single-answer questions and tasks typically defined in exam questions. The practical tasks were also largely aimed at repeating one-way, templated learned knowledge elements, and the students found them less of a creative opportunity. Qualitative forms of assessment, such as text assessment or well-founded, organized self-assessment and peer assessment (group work assessment), hardly occur, and the combination of different forms of assessment is also in low proportion. The evaluation method was, therefore, primarily quantitative and summative, which confirms the 4th hypothesis.

3.4 Student Workload and Support

Most of the responses, 72%, confirm that the transition to online education significantly influenced the learning process. This means difficulties in time planning and scheduling, an increase in study time (67% spent more time on it) in parallel with the increase in tasks (92% consider the tasks given too many). (Figure 8)

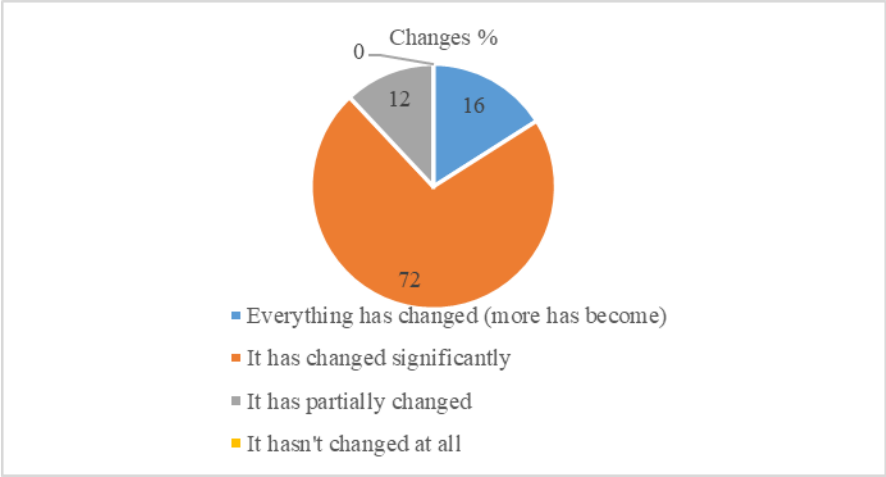

Figure 8
Changes in the ratio of tasks and individual work at home

Multiple loads, sometimes 3-4 times, have been reported. The students found the written or video course materials and the tasks to be completed too many. There was a subject from which a larger amount of assignments had to be sent to the teacher every week. The students were given auxiliary materials, case studies, and technical articles as homework, which they were also able to process in a longer time than average and with more investment of effort. In other subjects, it was just the opposite, the instructor hardly kept in touch, he or she called the students only to the exams.

The students also mentioned the deadline of the assignments as a stress factor. In the Moodle framework, for example, the deadline for availability and completion can be set, for which notifications are received, so this practical setting option becomes a tension-causing factor.

The students' participation in class also changed, it became a higher proportion according to their own admission and also from the perspective of the instructor. They were less likely to be absent from video conferences, group discussions and assignments than before in classroom settings. They have not exited the interface before, which is common, and even more common if they are in a hurry to another class or location. The background of this may be the phenomenon of confinement, or the transformation of time management and the omission of other activities, such as work, entertainment, individual programs. Connecting from home is also straightforward in many cases. Perhaps the controversial statement applies to this situation: "Information can be found on a computer, but the transmission of knowledge between generations can only be ensured by contact between people." [13]

67% of the students consider the difficulties of time planning and scheduling and the increase in study time to be problematic and too much. During the qualitative research, they say that it is almost self-training and that more time is needed for effective learning. At the same time, the respondents find the increase in the amount of tasks very problematic. 92% consider the tasks to be completed during the semester to be too many compared to the previous ones. This is attributed to the fact that the instructors want to ensure continuous learning and ensure that the students are not wasting their time. (Figure 9)

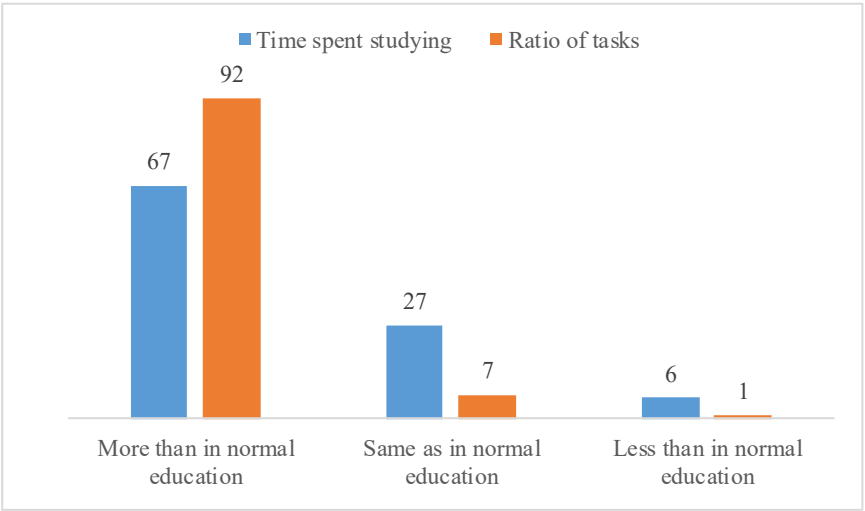

Figure 9
The ratio of study time to tasks

According to the students' statements, several teachers issued the assignment, but did not send feedback or merit evaluation. The assessment involved entering the grades, but no individualized feedback was given. According to 89%, the deficiencies in the holding of classes and the deficiencies in the online preparation of the instructors are weak. Overall more tasks were assigned to the students, for which they received little support. This supports hypothesis 4.

The results of some studies are similar in the sense that the students already had digital skills and that the instructor's teaching style has a motivational effect. However, there are differences, such as the positive effect of Covid awareness on institutional/faculty preparedness and students' willingness to participate, but it is important to prepare both sides for participation in online education. [14] Alea et al. similarly recommend that educational institutions review their approaches to e-learning policies during the pandemic and in general. [15] Some research points to the impact of the positive experience and quality of online learning on student satisfaction [16, 17] According to another study, the personal perception of e-learning influences the intention to participate in e-learning. We agree with many

others that one of the biggest challenges is the methodological and tool use readiness of teachers, that the old models do not adapt to changes and that in the future the factors that motivate students and teachers must be examined and prepared for a similar situation. [18, 19, 20]

Conclusion and Suggestions

The purpose of the study is not to comprehensively analyze the experiences of online education worldwide, but it tries to contribute to the successful implementation of the practice. The suggestions should also be considered in general, not only during a pandemic, but for adapting to digital education in general. They affect the whole of education, and in general, teacher training and the interpretation of the teacher's role. They should definitely be considered when preparing for an emergency situation. The results of the research show that digital education is not only a matter of material conditions, but requires preparation, knowledge, and skills on the part of both students and teachers. In many cases, the material conditions are incomplete, but their existence alone does not ensure successful implementation without the other side. In light of this, the creation of the following conditions is necessary and recommended for changes:

- Material and environmental conditions: knowledge and regular, daily use of digital tools is essential for the implementation of digital education. Where students or higher education students and teachers do not routinely use the devices, digital education is hindered. If certain skills, such as flexible switching, adaptation to the use of new platforms, or interpretation and understanding are incomplete, learning becomes slower. At the same time, the availability of tools and the skills and frequency of use are related, obviously skills cannot be developed in the absence of tools, and replacement is difficult even if the tool is provided. Tool and supporting preparations are therefore necessary.
- Personal conditions: the basis of successful learning is ensuring the unity of the external and internal environment. The immediate environment of the individual is the microenvironment, which, if it is not supportive of learning, will lack the atmosphere in which the individual's independent learning develops. Learning to learn therefore requires microenvironmental conditions, a supportive atmosphere that can create time, space, and a calm location. The attitude and receptiveness of smaller groups, such as school and university groups and teachers, is decisive, and in this the instructor has as important a role as the group mates. In order to fundamentally change the teacher's attitude, teachers should receive basic pedagogical and psychological preparation and master the supporting facilitator role instead of the traditional chair-centered role interpretation.
- Learning organization and methodological knowledge: since students do not have the same skills, the process must be supported from several sides. According to the principles of constructivist didactics, teaching also means

shaping learning environments. At the center of the learning process is the process of knowledge construction, the construction of one's own knowledge. It is the task of the teacher to create the learning environment, which means a system that integrates all important influencing factors. [21, 22] Although everyone creates their own mental model in order to understand their experiences and new information, the teacher's involvement is essential, which should appear precisely at those points when the process gets stuck. This requires proper contact and continuous interaction during learning. The knowledge-centered learning environment is not conducive to the mobilization of existing knowledge and the development of metacognition. The constructivist methodology therefore prefers a variety of learning sources, independent and collective ways of thinking in the spirit of variety. The various types of information and their collection can be most effectively realized through cooperation, pair or group work, so that each student can find different points of view, develop their own knowledge and, at the same time, control. Individualized research and other tasks, project-based learning, student presentations, and the teacher's question-explaining method also maintain learning motivation. They can only acquire the knowledge defined in the goals with various forms of work and methods, and only in this way can they acquire the skills necessary for social activities. For this, it is necessary to prepare the supporting methodology of the instructors, to update the knowledge and practical elements.

In conclusion, we have to agree that "if we want to change something, we depend to a large extent on (prospective) teachers changing their thinking - and therefore our thinking as teacher educators". [23]

In summary, in the words of György Molnár, "we must emphasize that the transformation of the teaching-learning process is much more important and significant than education". It is, therefore, necessary to make the framework flexible, reinterpret the teaching profession and role, renew the methodology and develop digital knowledge. [24]

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Industry 5.0: Generalized Definition, Key Applications, Opportunities and Threats

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Abstract: Collaboration between humans and machines is the main focus of the latest industrial revolution dubbed 'Industry 5.0'. This piece aims to highlight the overall concept, as well as the key applications, opportunities and threats of Industry 5.0. Various definitions of Industry 5.0 are presented, with a focus on the significance of human-robot cooperation and the priority placed on people and eco-friendliness in industrial processes. This article showcases the distinct and inventive customer experiences that Industry 5.0 provides, while also generating value for industrial companies. Additionally, a SWOT analysis delves into the strengths, weaknesses, opportunities and threats brought about by Industry 5.0. Achieving sustainable development goals and gaining a competitive edge are both possible for companies embracing Industry 5.0. Despite the benefits, however, obstacles abound. Issues like integrating human resources into production processes and tackling safety and ethical concerns require attention.

Keywords: Industry 5.0; Industry 4.0; human-machine cooperation; sustainability; SWOT analysis; sustainable development goals; safety issues; ethical issues; human resources

1 Introduction

A series of industrial revolutions have brought major changes in manufacturing and production. The term Industry 4.0 was publicly introduced at the Hannover Fair in 2011 [1], which developed the concept of Cyber-Physical Systems (CPS) into

Cyber-Physical Production Systems (CPPS) [2]. One of the key initiatives of Industry 4.0 is SmartFactory [3]. In the era of Industry 4.0, production systems, in the form of CPPS, can make intelligent decisions through real-time communication and collaboration between "manufacturing things" [4], enabling flexible manufacturing of high-quality personalised products with mass efficiency [5]. In Industry 4.0, the main priority is to automate processes, thereby reducing human intervention in the manufacturing process [6]. Industry 4.0 focuses on improving mass production and performance by digitalisation and AI-driven technologies to increase the efficiency and flexibility of production, but with less focus on social and sustainability principles.

The fifth industrial revolution, Industry 5.0, is an advancement of its predecessor, Industry 4.0, which was centered around automation and digitization. Industry 5.0 is a revolution that recognises industry's ability to achieve social goals alongside growth, putting people at the centre of the production process [6]. Industry 5.0 will place more emphasis on the human factor, customisation, environmental awareness, and the integration of new technologies than previous industrial revolutions. The introduction of Industry 5.0 is based on the fact that Industry 4.0 focuses less on social and sustainability principles and more on increasing the efficiency and flexibility of production [7]. Figure 1 summarizes the industrial revolutions.

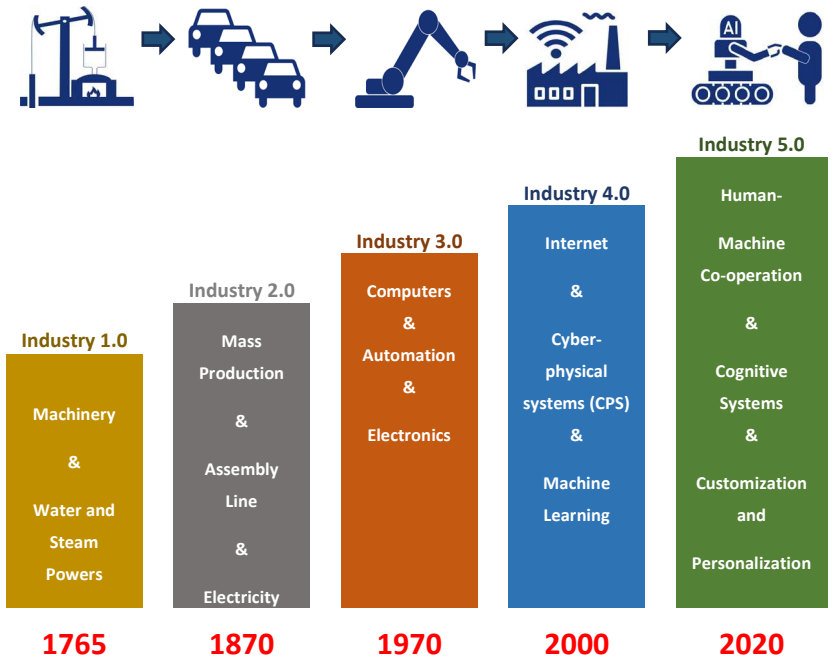

Figure 1
Industrial revolutions

Industry 5.0's focus lies in enhancing the collaboration between humans and machines. Its goal is to improve workplace safety, reduce errors, and boost productivity by optimizing human-machine interaction [8]. The combination of creative human input and smart technology defines the Industry 5.0 model. It allows for workers to not only participate in the production process, but also make important decisions and adapt to shifting circumstances in real-time. Working in conjunction with each other instead of being replaced, Industry 5.0 and Industry 4.0 harmoniously bring forth optimal results for manufacturing and industry. Human-machine collaboration, sustainability and cybersecurity will be key elements of the new industrial revolution.

This paper summarizes the definitions of Industry 5.0 and give a generalized concept for Industry 5.0 applications. Based on a synthesized analysis, it reflects the key applications of Industry 5.0 with the help of a detailed SWOT analysis and highlights the main opportunities and threats of the fifth industrial revolution.

2 Generalized Definition of Industry 5.0

Industry 5.0 is still constantly developing, so experts and researchers from different perspectives have given different definitions for the discussion of this industrial revolution. Since the concept of Industry 5.0 has not yet fully matured, so some general and more specific definitions are summarized below:

- Def1: “The revolution of industry 5.0 means that humans and machines are working together, improving the efficiency of industrial production. Human workers and universal robots are boosting the productivity of the manufacturing industry.” by Amr Adel [9]
- Def2: “Industry 5.0 can be considered the era of the socially intelligent factory, in which cobots converse with people. Enterprise social networks will be used by Social Smart Factory for enabling seamless communication between human and CPPS components. The overall current understanding of Industry 5.0 brings the human touch back to the industry. It also entails the incorporation of AI into human operations to enhance man's capacity. The core of Industry 5.0 is the harmony of machines, humans, values, tasks, and finally, knowledge and skills which results in personalized/individualized products as well as services.” by Leng *et al.* [10].
- Def3: “The Age of Augmentation (Industry 5.0)—will be focused on the cooperation between human intelligence and cognitive computing and on treating automation as a further enhancement of the human’s physical, sensorial, and cognitive capabilities. By putting humans back into the loop, Industry 5.0 profoundly restructures human tasks in the realm of

manufacturing in ways that benefit the workers. They will be upskilled to shift from manual to cognitive labor, to provide value-added tasks in production and to work—with peace of mind—alongside an autonomous workforce, i.e., collaborative robots that will be perceptive and informed about human intention and desire" by Francesco Longo, Antonio Padovano and Steven Umbrello [8].

- Def4: "This approach provides a vison of industry that aims beyond efficiency and productivity as the sole goals, and reinforces the role and the contribution of industry to society. It places the wellbeing of the worker at the centre of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet. It complements the existing "Industry 4.0" approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric and resilient European industry." by European Commission [11].
- Def5: "INDUSTRY 5.0 is future, but already penetrating trend, of change processes directing towards closer cooperation between man and machine, and systematic prevention of waste and wasting including INDUSTRIAL UPCYCLING. INDUSTRY 5.0 priority is to utilize efficiently workforce of machines and people, in synergy environment. It goes back from virtual environment to real one." by Michael Rada [12].
- Def6: "Bringing back human workers to the factory floors, the Fifth Industrial Revolution will pair human and machine to further utilize human brainpower and creativity to increase process efficiency by combining workflows with intelligent systems. While the main concern in Industry 4.0 is about automation, Industry 5.0 will be a synergy between humans and autonomous machines." by Saeid Nahavandi [13].
- Def7: "In other words, at its heart, Industry 5.0 reflects a shift from a focus on economic value to a focus on societal value, and a shift in focus from welfare to wellbeing." by Jeroen Kraaijenbrink [14].
- Def8: "The 5th Industrial Revolution, which still is emerging, is bent on fostering cooperation between humans, machines, and technology to ensure the stability the workforce and an understanding of worker empowerment." by MOMENTA [15]
- Def9: "The previous tier, Industry 4.0, emerged with the arrival of automation technologies, IoT and the smart factory. Industry 5.0 takes the next step, which involves leveraging the collaboration between increasingly powerful and accurate machinery and the unique creative potential of the human being." by Nexus Integra [16].
- Def10: "The term Industry 5.0 refers to people working alongside robots and smart machines. It's about robots helping humans work better and faster by leveraging advanced technologies like the Internet of Things (IoT) and big

data. It adds a personal human touch to the Industry 4.0 pillars of automation and efficiency." "The pairing of human and machine workers opens the door to countless opportunities in manufacturing. And since the use cases of Industry 5.0 are still in their relative infancy, manufacturers should be actively strategizing ways to integrate human and machine workers in order to maximize the unique benefits that can be reaped as the movement continues to evolve." by James Jardine [17].

- Def11: "The Fifth Industrial Revolution, also known as Industry 5.0, is a new phase of industrialisation, whereby humans work alongside advanced technologies and AI-powered robots to enhance processes within the workplace." by Marina Ruggieri [18].
- Def12: "Industry 5.0, also known as the Fifth Industrial Revolution, is a new and emerging phase of industrialisation that sees humans working alongside advanced technology and A.I.-powered robots to enhance workplace processes. This is coupled with a more human-centric focus as well as increased resilience and an improved focus on sustainability." by TWI [19]

Based on the previous definitions, a synthesized generalized definition for Industry 5.0:

Industry 5.0 focuses on effective human co-work with machines to increase flexibility and sustainability by relying on smart machines.

Industry 5.0 builds on the achievements of Industry 4.0, but rather than replacing humans, it aims to exploit the potential of human intelligence in human-machine interaction more than ever before. This will allow people to use their cognitive abilities and rapid adaptability to improve without sacrificing the accuracy and consistency offered by intelligent machines. In this way, Industry 5.0 focuses on economic, environmental and social impact to make sustainable choices.

Figure 2
Industry 5.0 from the perspective of human-centric sustainability [15]

3 Key Application Areas of Industry 5.0

The following key application areas can be identified for Industry 5.0, the latest industrial revolution that focusing on collaborating with smart technologies to boost production efficiency and improve the workplace environment by combining human creativity with machines. Industry 5.0 has brought a number of innovations and differences compared to previous industrial revolutions, including:

- Human-Machine Collaboration: at the heart of Industry 5.0 is human-machine collaboration. While Industry 4.0 focused on full automation and autonomous systems, Industry 5.0 aims to combine human creativity with machine efficiency.
- Tailored Production: Industry 5.0 will allow manufacturing processes to be customised to individual needs. This means that companies will be able to produce unique products in high volumes without losing efficiency.
- Environmentally conscious: The new industrial revolution places a strong emphasis on sustainability and environmental protection. Companies need to operate not only more efficiently, but also in a more environmentally friendly way.
- Digital Twins and Augmented Reality. These technologies enable virtual modelling and optimisation of production processes.
- Intelligent Systems. This means that systems can anticipate problems and solve them before they become serious problems.
- Cybersecurity. As systems become more complex and interconnected, security risks will increase and companies will need to focus more on cybersecurity.

Putting human creativity and intelligent technology together, Industry 5.0 is the next industrial revolution focusing on man-machine partnership. This revolution aims to amalgam production efficiency and workplace environment. Taking into account these development trends, the following key application areas can be identified with regard to Industry 5.0:

- Collaborative robots (Cobots): These robots work alongside humans on the production line and are able to learn from their human co-workers. Cobots are able to identify and adapt to the activities of their human colleagues, creating a safer and more efficient work environment.
- Cognitive robotics: Cognitive robots are able to learn and adapt to their environment by the intelligent behavior of robots. These robots are able to make decisions independently and collaborate with humans in production processes.

- Digital Twins: Digital twins are virtual copies of physical devices that collect real-time data and perform analytics. These twins help companies to develop and optimize production processes and predict maintenance needs.
- Augmented Reality (AR) and Virtual Reality (VR): AR and VR technologies allow workers to interactively connect with production processes, increasing productivity and efficiency. In addition, these technologies can be used for training and educational purposes.
- Intelligent manufacturing systems: The goal of Industry 5.0 is to create intelligent manufacturing systems that can identify and solve manufacturing problems and achieve maximum efficiency and flexibility by combining human cognitive abilities with machine precision.
- Intelligent healthcare: It can individually monitor the patient's condition and provide personalized treatment with the help of doctors. With the help of cobots, doctors can perform surgeries in cooperation with robots. Routine medical tasks can also be performed by cobots, so doctors can focus on more complex tasks.
- Customized production: Industry 5.0 enables companies to produce customized products according to customer needs by combining the power of humans and smart manufacturing. This includes customizing products and modifying manufacturing processes to customer specifications. It allows companies to produce uniquely customized products instead of mass production. With this method, companies will be able to respond quickly to market changes and customer needs.
- Data-driven decision making: The concept of Industry 5.0 also includes data-based decision making. With the help of smart sensors and IoT devices and humans, companies are able to collect and analyze data to make better decisions about manufacturing processes.
- Education: The combination of smart machines and better trained professionals results in efficient, sustainable and safe production. Industry 5.0 introduces the role of Lead Robotics. This person specializes in machine-operator interaction and has experience in areas such as robotics and AI. Education must reflect this when training future specialists and engineers.

Innovation in Industry 5.0 is bridging human involvement and technology during production. Exciting new applications resulting from technological advancements have the potential to revolutionize the industrial sector. The sparse examples of potential applications shown here are just a taste of the possibilities Industry 5.0 offers.

4 Examination of Opportunities and Threats using SWOT Analysis

The examination of Industry 5.0 opportunities and threats is carried out with the help of a SWOT analysis. For the analysis, it was summarized on the basis of the authors' characterizations related to industrial applications, based on a synthetic overview of many Industry 4.0 and Industry 5.0 papers. The papers used for the analysis can be classified into the following groups:

- general overviews [2], [10], [19], [20]
- industrial and medical applications and research [21], [22], [23], [24]
- management, innovation, economy [25], [26], [27]
- socio and human centric perspectives [6], [8], [9], [28], [29], [30]

Table 1 shows the summarized results of a SWOT analysis based on a synthesis of the literature reviewed.

Table 1
SWOT analysis of Industry 5.0 technologies

SWOT	Content
Strengths	**1. Human and Machine Collaboration**: Emphasizes the interaction between humans and machines, promoting a collaborative environment. Combines human creativity with machine efficiency to enhance productivity and improve workplace safety. **2. Human-Centric Approach**: Puts human needs and interests at the center of the production process. Industry 5.0 prioritizes the well-being of industrial workers, emphasizing their importance in the production process. **3. Customized Production**: Enables tailoring of manufacturing processes to individual needs. **4. Organizational Resilience**: Industry 5.0 focuses on resilience, allowing industries to adapt and thrive in changing conditions. **5. Environmentally Conscious**: Places a strong emphasis on sustainability and environmental protection. **6. Digital Twins and Augmented Reality**: Introduces digital twin and augmented reality technologies into manufacturing processes. **7. Technological Advancements**: The integration of advanced technologies such as IoT, AI, and robotics to create flexible and efficient production systems. **8. Sustainable Manufacturing**: Manufacturing must respect planetary boundaries and be sustainable. The industry meets societal demands while respecting planetary boundaries.
Weaknesses	**1. Complex Technologies**: Introduction and integration of new technologies can pose complex challenges for companies.

	2. Training Requirement: Workers need to acquire new skills for the effective use of new technologies. **3. Social Heterogeneity**: There can be societal differences in values and acceptance. **4. Transition Challenges**: Moving from Industry 4.0 to 5.0 might pose challenges, especially for industries heavily invested in the former. **5. Data Security and Interoperability**: Concerns related to ensuring data security and interoperability between systems. **6. Potential Resistance**: Traditional industries might resist the change due to the costs and complexities involved in the transition. **7. Lack of Clear Definition**: Being a topic in development, there's no precise consensus on its definition, which can lead to confusion and misinterpretation.
Opportunities	**1. Competitive Advantage**: Companies that successfully implement Industry 5.0 technologies can gain a competitive edge in the market. **2. Sustainable Growth**: Environmentally conscious manufacturing processes allow companies to achieve sustainable growth in the long run. **3. Resilience**: Manufacturing must be capable of defending against disruptions and ensuring critical infrastructure during crises. **4. Meeting Societal Demands**: Industry 5.0 offers the chance to realign industries with societal needs, potentially opening new markets and avenues for growth. **5. Innovation and Entrepreneurship**: The emphasis on creating an environment conducive to innovation can lead to the birth of new ideas, products, and services. **6. Strengthening Partnerships**: There's an opportunity to strengthen collaborations between the public and private sectors, leading to shared growth and development. **7. Addressing Global Challenges**: The ability to address significant global challenges such as climate change, rapid consumption of non-renewable resources, environmental pollution, and social injustice.
Threats	**1. Cybersecurity Risks**: As systems become more complex and interconnected, security risks increase. **2. High Initial Investment**: Introduction of Industry 5.0 technologies may require significant initial investment. **3. Productivity Challenges**: Significant investments are needed while also expecting an increase in productivity. **4. Rapid Technological Changes**: The pace of technological advancement might outstrip the industry's ability to adapt, leading to potential inefficiencies. **5. Environmental and Social Challenges**: Issues like climate change, environmental pollution, and social injustice can pose significant challenges to the successful implementation of Industry 5.0.

	6. Potential Overshadowing by Industry 4.0: The existing prominence and momentum of Industry 4.0 might overshadow the newer paradigm, slowing down its adoption. **7. Global Conflicts**: Events like the Russia-Ukraine conflict can elevate complexities in the global industrial context.

5 Insights into Practical Applications and Future Directions of Industry 5.0

At the brink of the new industrial revolution, we witness an amalgamation of cutting-edge technologies and human-centered methods that will bring some significant changes to several industries. Industry 5.0 signifies not only a technological advancement but also a paradigm shift in the operation and growth of businesses. Our scrutiny will explore Industry 5.0's practicability and future prospects, scrutinizing its effect on agriculture, healthcare, and manufacturing while examining future technology progressions, workforce dynamics, and expertise demands. Our investigation targets a comprehensive perception of the opportunities and obstacles Industry 5.0 will present in this impending industrial era.

Industry 5.0 is set to revolutionize various sectors by bringing in more efficient, sustainable, and customized approaches. The future will see advancements in AI, robotics, IoT, and data analytics enhancing human-machine collaboration. This evolution will fundamentally alter the job landscape, necessitating a shift in education and skills development. Embracing these changes is crucial for industries to remain competitive and sustainable in the rapidly evolving technological world.

5.1 Manufacturing

Introducing a paradigm shift in the manufacturing sector, Industry 5.0 is transforming production processes into something more efficient, sustainable, and customized. This envelopment is characterized by the integration of advanced technologies such as AI, robotics, and IoT, allowing machines to support human creativity and decision making rather than just automating tasks. The main focus is to enhance human-machine collaboration, resulting in an agile production line that meets individualized customer needs, reduces waste, and improves resource efficiency. Consequently, this synergy leads to a manufacturing landscape that is more responsive and responsible, in line with the rising demand for sustainability.

5.2 Healthcare

In healthcare, Industry 5.0's potential is transformative. The use of collaborative robots (cobots) and AI in surgeries and patient care marks a significant advancement. Cobots, designed to work alongside human professionals, can assist in complex surgical procedures, offering precision and consistency beyond human capabilities. AI algorithms can process vast amounts of patient data, aiding in diagnosis and personalized treatment plans. These technologies not only enhance the quality of care but also promise to make healthcare more accessible, as they can assist in overcoming human resource constraints in underserved areas.

5.3 Agriculture

In agriculture, Industry 5.0 technologies play a pivotal role in ushering in an era of precision farming. This approach leverages IoT sensors, AI, and big data analytics to make farming practices more informed and precise. From soil moisture sensors guiding irrigation to AI-driven pest control solutions, these technologies enable better resource management, higher crop yields, and reduced environmental impact. Precision farming epitomizes the Industry 5.0 ethos of harmonizing efficiency with sustainability.

5.4 AI and Robotics

Looking ahead, further advancements in AI and robotics promise to deepen human-machine collaboration. Next-generation AI could offer more intuitive and adaptive learning capabilities, aligning closely with human needs and thought processes. Robotics might evolve to be even more flexible and capable of complex, creative tasks, blurring the lines between tasks traditionally thought to be exclusively human or machine domain.

5.5 IoT and Data Analytics

The advancements in IoT and data analytics herald a future where industrial processes are not only more efficient but also more sustainable. Enhanced IoT connectivity will lead to smarter factories, where real-time data analytics can optimize energy use, reduce downtime, and predict maintenance needs. This level of operational intelligence paves the way for industries to not only increase their productivity but also significantly lower their environmental footprint.

6 Discussion

Industry 5.0, this novel concept highlights the significance of prioritizing people and sustainability in industrial processes. More importantly, this new paradigm emphasizes the crucial role of industrial workers in the production process, nurturing collaboration and coordination between human and smart systems. This integration gives rise to the possibility of individualizing products and services on a massive scale, providing unparalleled and innovative customer experiences. Consequently, this creates value and establishes a competitive edge for industrial enterprises. Blending technology with innovative tactics and organizational frameworks is key. The structure, functioning, human resources, and operations of corporations must harmonize with societal demands and stakeholders. To inaugurate a culture of creativity and business, establishing a favorable environment is imperative. Crafting a skilled workforce, investing in R&D, and strengthening public-private sector collaboration must be prioritized. Achievement of sustainable development goals is possible only if industries make themselves resilient, integrate human values with technology and ensure sustainability. Competition and productivity must be weighed against said goals also considering the technological advancements that accompany the new industrial revolution.

People-centeredness and sustainability are the key priorities of Industry 5.0, prompting a paradigm shift in the industrial sector. By placing human needs and interests at the core of the production process, a human-centered approach emphasizes the significance of the human touch over technological advancement. Additionally, this approach brings about fresh roles for industrial workers, as the value perception shifts from viewing them as "costs" to recognizing them as "investments.

In Industry 5.0, the focus is on people and societies, rather than mere technology. To adapt to the diverse needs of industrial workers, the manufacturing industry uses technology that caters to them. The goal is to create a work environment that prioritizes employee well-being, including their physical and mental health. This approach puts emphasis on protecting workers' fundamental rights, such as autonomy, human dignity, and data protection.

For a more balanced work-life and improved career options, industrial employees must constantly train and develop themselves [31] [32]. Additionally, Industry 5.0 prioritizes sustainable manufacturing and encourages industries to be sustainable and respectful of the planet's limitations. One way to achieve this is by creating circular processes that repurpose, recycle and reuse natural resources, ultimately leading to an efficient and sustainable circular economy with less waste and environmental impact.

Industrial production in Industry 5.0 is required to display resilience as a critical strength. This resilience is necessary to combat disruptions and protect crucial

infrastructure. The industry of the future must be agile enough to adapt efficiently to (geo-)political transformations and unforeseen natural emergencies.

The COVID-19 crisis has, in particular, made apparent the fragility of global supply chains and reinforced the necessity for better preparation for the future. Utilizing a host of cutting-edge technologies like the Internet of Things, blockchain, and the latest 6G networks, Industry 5.0 has emerged as a game-changer. By leveraging the power of digital twins, collaborative robots, and edge computing, the entire production process can be monitored and controlled for optimal efficiency and superior quality. Thanks to 3D modeling and simulation, product designs can be perfected and stored digitally before being manufactured on demand, making the storage of large quantities of finished products a thing of the past, and bringing down the costs of inventory management.

Industry 5.0 allows for mass customization, which means that personalized products can be created based on customers' preferences and requirements. This innovation enhances production efficiency and facilitates an interactive and continuous monitoring process between humans and machines. Responsibility for these activities is shared, resulting in increased flexibility.

Identifying alternate routes in the face of disturbances remains paramount in Industry 5.0. Such resiliency can only be achieved with the help of digital tools and methods - think simulations and advanced AI models - that can weigh diverse factors like quality, cost, logistics, and substitution.

The application of Industry 5.0 is not without its share of difficulties and drawbacks. Despite its numerous benefits, one primary issue is social heterogeneity. There exists a vast diversity of values and social norms; thus, people tend to differ in their acceptance of new technologies and methods. Consequently, such diversity poses a considerable challenge in the adoption of Industry 5.0 since individuals come from different backgrounds and hold distinct viewpoints that can influence their perspectives.

In Industry 5.0, the integration hurdle poses a challenge to its stakeholders, customers to SMEs. Coping with technology advancements can also make research and development more complex, given the interdisciplinary research fields and intricate systems in play. Incorporating innovation policies that prioritize the ecosystem poses its own set of difficulties. The industry's rapidly shifting climate necessitates agile and results-driven approaches, which presents yet another challenge. The adoption of adaptable and flexible Industry 5.0 innovation methodologies is, therefore, imperative. To thrive in Industry 5.0, businesses must boost productivity through significant capital investments. However, this presents challenges for those with limited resources. Before taking the plunge, companies must thoroughly weigh the rewards and hazards of embracing these technologies.

The connection between Industry 5.0 and eye tracking systems lies in the fact that both areas aim at human-artificial intelligence cooperation and improving the

efficiency of work processes and can be fundamental elements of the future manufacturing and technological environment. Eye movement tracking systems can also be used during the examination of complex cognitive processes such as programming [31-33], with the support of which the efficiency of the process can be improved and expanded using artificial intelligence. Immersive VR [34] is, therefore, compatible with the principles of Industry 5.0 and enables effective collaboration between people and intelligent systems, increasing flexibility and innovation in production and work processes.

Digitalization and IoT devices pose a major problem for Industry 5.0 - security. The use of heterogeneous data management and cloud services exacerbates the issue as the number of vulnerabilities rises with them. Data security is a crucial aspect of Industry 5.0, where mutual trust among various stakeholders like IoT nodes, machines, and communication nodes is established through authentication. Data integrity is also vital as control commands and monitoring data pass through third-party networks. System performance must not be harmed while ensuring integrity enforcement. Privacy and data protection are key considerations in Industry 5.0. The advanced cognitive capabilities of manufacturing processes give rise to the potential for highly customized services, but this also brings ethical issues and challenges in safeguarding privacy during data collection.

In order to reintegrate human resources into the production line, effective training is required for both humans and machines to successfully cooperate. The challenge lies in scaling users and production processes, particularly in the realm of human-robot collaboration. This can prove to be a hurdle for the seamless partnership between human intelligence and machines. AI's ethical concerns shouldn't be disregarded. Every application of AI calls on us to scrutinize the advantages and social implications. Ethical repercussions also take a critical place for success. Finally, ethical matters are the last piece of the puzzle. The measurement of environmental and social value remains an unreliable quest for Industry 5.0, despite its goal of creating such values. For organizations seeking to evaluate the efficacy of their sustainability initiatives, this presents a challenge. Industry 5.0 requires more skilled jobs and these are mainly focused on product customisation, with a strong emphasis on increasing customer satisfaction. In Industry 5.0, the majority of the production process will still be automated, but the real-time processed data from machines will provide the opportunity to collaborate with highly skilled professionals [37] [38]. Another key benefit of Industry 5.0 could be the use of greener solutions through people working together to achieve pollution-free manufacturing processes, as opposed to purely manufacturing-centric solutions.

Conclusions

Industry 5.0 relies on smart machines that maximise flexibility and sustainability, while leveraging human-machine collaboration. While Industry 4.0 focuses on technologies such as the Internet of Things or big data, Industry 5.0 focuses on human, environmental and social aspects. In this respect, Industry 5.0 complements

the achievements of Industry 4.0 and does not necessarily replace humans but promotes human-machine collaboration. This will allow humans to focus primarily not on performing parts of the control, but to incorporate human critical thinking and adaptability, while still taking advantage of the accuracy and repeatability of machines.

Technological development is no longer the sole focus of Industry 5.0, which now prioritizes social values and human involvement. Through human-machine collaboration, the production processes can be customized to provide personalized customer experiences. With an emphasis on environmental responsibility and social improvement, Industry 5.0 pioneers a paradigm shift.

Industry 5.0's application of technology and innovation allows companies to meet customers' distinctive demands while adjusting to an environment that is quickly evolving. Transforming the work atmosphere is accomplished through focusing on individuals and their growth. Ongoing learning and training play a significant role in workforce development and culture.

Industry 5.0 harnesses the unique creativity of human experts to work efficiently, smartly and accurately with machines. Many tech professionals believe that Industry 5.0 will bring back human intervention and combine high-speed and accurate machines with the critical, cognitive thinking of humans. Industry 5.0 can improve the quality of production by assigning repetitive and monotonous tasks to robots/machines and critical thinking tasks to humans.

Industry 5.0 poses many obstacles, including the incorporation of modern technology, managing moral dilemmas, and maintaining a symbiotic relationship between man and machine. To overcome these hurdles, it is crucial for industries to collaborate more closely and funnel resources into further research and development. The future of industry is set to integrate human values and technological innovation to create sustainable and human-centered industrial processes through Industry 5.0. This will pave the way for a more inclusive and sustainable society, where a delicate balance between industry growth and human values is achieved.

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