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.:

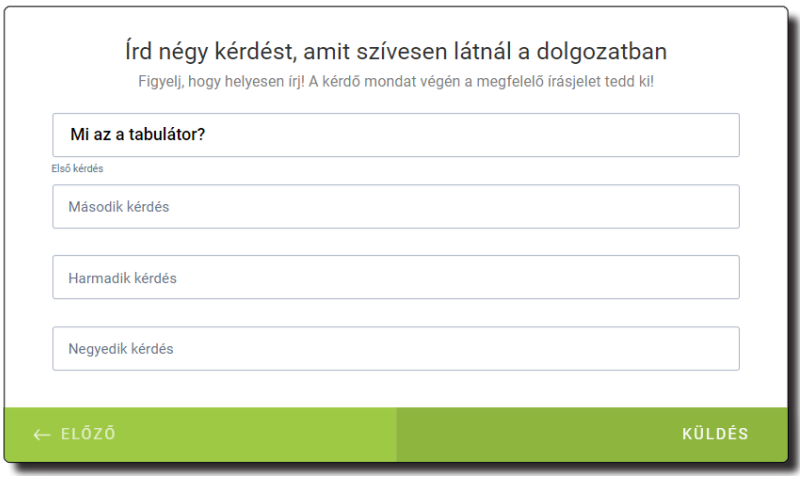

Figure 1
AI-ased user interface

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.

Acknowledgements

I would like to express my gratitude to Adrienn Dineva, teacher, for her assistance in developing machine learning models and to the dean of Óbuda University. I am thankful to Artúr Kiss for his continuous help and support in my research, and also to the Veszprém district educational center (Veszprémi Tankerületi Központ), Várkerti Elementary School, and its affiliated institutions.

This paper was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences for Zoltán Szűts.

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