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EFFECTIVE LEARNING STRATEGIES AND ARTIFICIAL INTELLIGENCE (AI) SUPPORT FOR ACCELERATED MATH ACQUISITION

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Abstract

Results in learning mathematics leads to a conclusion that students' perception have changed and traditional learning methods are not so effective as they were before. As mathematics has a great influence on future professions, the question is: "How to make developing of mathematical skills faster in the age of smart technologies?" The purpose is to identify effective learning strategies and support of AI that promotes students' motivation and improves attitude in long term. In the future it will promote development of qualitative support system for teachers of mathematics what correspond to demands of "The fourth industry". Research methodology includes research methods of students` attitude and pedagogical processes. A survey of 183 students has been conducted during 3 years and a selection of effective learning strategies created, identifying the positive impact on indexed students' preferences. Possibilities of AI support for accelerated learning of mathematical skills have been identified, converging on created strategies. The assessment provided in the research can help teachers to choose the most appropriate strategies for students' learning style to make learning more exciting and digital. AI has so many positive features that its support in the future can complement or even replace current learning strategies. Different strategies are necessary 1) to cover all the students' wishes identified in the research; 2) because students learn mathematics at a different pace and according to previous knowledge. In turn, effective methods based on research, Big Data and AI can make mathematics a more accessible and meaningful subject in the future.

Keywords: Mathematics, effective learning strategies, Artificial Intelligence.

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1. Introduction

Eurydice (2011) research has identified mathematical competence as one of the most important competences needed for people to be able to fulfil themselves, to take an active part in civic and social life and to build their professional careers in the knowledge society successfully. The term “mathematical competence” includes not only the basics of numeracy, but also knowledge, skills and attitudes. In addition, Eurydice research on mathematics education has shown that improving attitudes and learning outcomes in mathematics can be achieved through using more modern teaching methods, adapting to students' needs, using IT capabilities, developing effective teaching strategies, researching teaching methods and assessment tools, involving parents and entrepreneurs as well as adapting the school environment. When students are motivated to learn mathematics, they devote more time to mathematics tasks and solve them more persistently, as well as are happy to take additional mathematics courses and choose a future profession related to mathematics. Teaching methods and tasks must be exciting, varied and relevant to students' daily lives.

2. Problem Statement

However, several important studies indicate that there are problems with the acquisition of these skills in Latvia: (1) The Eurydice studies indicate that “23% of 15-year-olds in Latvia have low achievements in mathematics, moreover, there is also a lack of modern technology use in the learning processes”; (2) OECD (PISA, 2018) : “Only 7.2% of 15-year-old students in Latvia wish to become professionals in natural sciences or engineering fields in the future (while in OECD countries – 8.6%)”; (3) Research on the centralized examination results in Latvian schools, conducted by the Latvian Association of Local and Regional Governments (Dundure & Upenieks, 2017), shows that the worst exam results are usually in mathematics (34.85%); (4) According to a 2015 study on why parents hire private tutors , done by the Baltic Centre for Investigative Journalism “Re: Baltica” and media partners, 55% of parents hire private tutors for mathematics (Vītola & Tupiņa, 2015).

Poor learning outcomes in mathematics suggest that students' perceptions and interests have changed, and that old (traditional) teaching methods are no longer as effective as before and new solutions need to be found. In research “It`s Learning. Just not as we know it” by Accenture in 2018 it is pointed out that it is time to use the latest learning methods and approaches, as well as help policy makers and heads of educational institutions, implement innovative strategies that will change the way we teach and learn.

3. Research Questions

When teaching mathematics to first-year students at Vidzeme University of Applied Sciences in Latvia, during a 3-year period, the author surveyed a total of 183 students from many Latvian schools to find out what motivates and inspires them to learn mathematics so that it creates joy and greater understanding of the subject. Students were able to give answers in a free form, remembering their school years and learning mathematics in different classes with different teachers. In the end, 220 specific responses with important approaches were obtained, which could be indexed to 23 specific desires (Figure 01) that motivate students to learn math more successfully.

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Index	Students' desires	Index	Students' desires	Index	Students' desires
1.	Good explanation by the teacher	9.	Clear presentation	17.	Good marks
2.	Real examples from life	10.	Individual approach	18.	Geometry tasks
3.	Lots of independent and homework	11.	Calculation at the blackboard	19.	Development of logical thinking
4.	Interesting learning approaches	12.	Understanding the usefulness	20.	Excitement and competition
5.	Repetition and practical examples	13.	Creative and problem-solving tasks	21.	Use of technologies
6.	Materials are posted on the Internet site	14.	Writing summaries	22.	More complex tasks
7.	Understanding of the topic	15.	Explanations of classmates	23.	Several solutions
8.	Humor and good attitude	16.	Feedback from the teacher		

Figure 01. Desires that motivate students to learn math more successfully

As shown in Figure 02, to the question "What inspires students to learn math better?" the answer "Good explanation by the teacher" has gained the most popularity or 32%. In turn, 28% of the answers indicate the desire to see real examples from life in mathematics lessons. 25% of the answers indicate that the students have done a lot of independent and homework, which has inspired them to understand mathematics better and better. Many student responses indicate that motivating factors include: interesting learning approaches (19%), continuous repetition and practical examples (14%), online learning materials (14%), understanding of the topic (14%), humour and good attitude (13%), presentations (10%), individual approach (6%), calling students in front of the class at the blackboard (5%), understanding of application (5%), creative and problem-solving tasks (5%). The following were also mentioned as important inspiring factors: help and explanation of classmates, feedback from the teacher, good marks, development of thinking, excitement and competition with others, use of technologies, more complex tasks, several methods of solving one task.

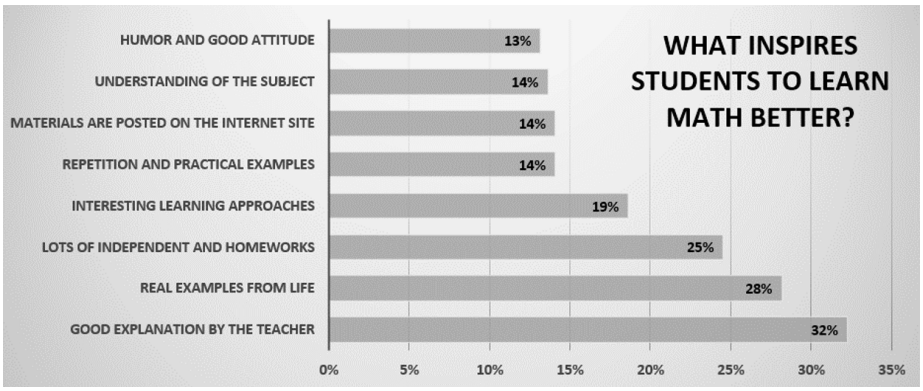

Figure 02. What inspires students to learn math better?

In turn, to the question "Did and what technologies did you use in mathematics lessons?" in January 2020, just before the COVID-19 emergency, when all education systems around the world switched to distance learning, students' responses were astonishing. Only 53% of the surveyed students admitted that technologies were used in the process of teaching mathematics, and very few and specifical programs such as Excel, SPSS, MathLab, Geogebra, GraphSketch, Photomath, Kahoot, Eduspace.lv, Uzdevumi.lv, Moodle and Interactive whiteboard options.

Taking into account the results of the survey, the rapid development of technologies and neuro-education, as well as the demand for digital skills, the key research questions are: (1) "What are the most

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effective learning strategies for accelerated learning in mathematics?" and (2) "How to accelerate the acquisition of mathematical skills in the age of smart technologies?"

4. Purpose of the Study

Mathematics is one of the most important and least understood subjects in schools. However, it is a subject that students will need for the rest of their lives. Students have always tried to understand mathematics through the most acceptable teaching methods, and teachers have always looked for the most effective strategies for better learning of mathematics. Researches over the past twenty years (Accenture, 2018; Levy & Murnane, 2004; Strong et al., 2004) have helped math educators to develop an understanding of effective teaching because the changing work environment has a major impact on the current younger generation. Computerization and globalization in today's world mean that students need to be able to solve problems much more and think critically. The need for students to acquire these skills also means that teachers need to learn new learning strategies - especially to help students see the connection between the real world and mathematics.

The aim of the author's research is to identify effective learning strategies and AI support opportunities for learning mathematics that promote student motivation and improve attitudes in the long run. In the future, this will contribute to the development of an appropriate and high-quality support system for mathematics teachers to stimulate the emergence of innovative learning approaches that meet the requirements of the Fourth Industry.

5. Research Methods

Research methodology includes qualitative, research methods of pedagogical process and students' attitude (focus group discussions, interviews, lesson observations, discussions, content analysis, social environment research, pedagogical situation analysis). Specifically: (1) Student survey during 3 years for 183 first-year students of Vidzeme University of Applied Sciences, who represent the whole Latvia with the largest part of students coming from Vidzeme region; (2) Compilation, analysis, comparison of survey results and indexation of motivational factors in learning mathematics; (3) Selection and brief description of the eight most effective teaching strategies based on experience of 30 years teaching mathematics and observing lessons, teacher success stories from around the world and experts' advice; (4) Qualitative evaluation of learning strategies, determining the positive features and impact on students' expectations, which are indexed according to the results of the research; (5) In accordance with the learning strategies, opportunities for AI support have been identified with the aim of conducting research in the future on the accelerated acquisition of mathematical skills in the age of smart technologies.

5.1. Effective teaching strategies

Mathematics teaching strategies are a set of tools that provide support to teachers, similar to navigation systems for travellers. Mathematics education is also constantly developing. Mathematics teaching strategies and methods that were popular several years ago are now being replaced by more effective research and Big Data-based methods aimed at making mathematics a more accessible and meaningful subject (Persico, 2019).

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Based on work experience of 30 years of observing mathematics lessons, teachers' success stories from around the world and experts' advice, eight learning strategies were purposefully selected and viewed as the most effective, which, when combined, could fully cover all indexed 23 student desires listed in Figure 01.

5.2. Open-Endedness Strategy

According to research (Mihajlovic, 2015; Maker & Schiever, 2010; Yuli, 2008), open problems can improve students' understanding and promote mathematical creativity by motivating students to develop their ideas. Tasks are considered open if their starting or target situation is not specified. Open problems usually have more than one solution and can be accomplished in more than one way. This leaves students free to solve the task and allows them to use different ways of thinking. Open problem learning activities are provocative and stimulate different thinking on a particular topic. Teachers' attitudes, assessment criteria and procedures are essential in this process, encouraging students to choose different solutions and offer creative answers. Students have the opportunity to express themselves as creative mathematicians. The method works very well in mixed classrooms, where the level of knowledge of students is from the lowest to the highest, because everyone can provide answers according to their knowledge and skills. The teacher has the opportunity to find tasks, the simplest of which are possible for all students in the class, but higher levels of difficulty challenge the abilities of the most talented students.

A good example of an Open-Endedness strategy in mathematics lessons is the task: 10 participants come to the seminar, each shaking hand with each one exactly once. How many handshakes have occurred? There is only one answer - and there are 45, but there are at least seven solution methods: looking at all possibilities, with the help of graphs, with the help of visualization, with the help of a table, with the method of mathematical induction, with combinatorial formulas. Finally, students can be asked to find a general case for the task.

5.3. Visual Representation

It is said that a picture is worth a thousand words. This is especially true in mathematics, where an image or some other type of visual model can be useful in describing a mathematical idea (Tenannt, 2006). In addition, models have proven to be useful for gaining a deeper understanding of the abstract concept and as a tool for problem solving. Over the last twenty years, with the development of computer visual imaging capabilities, a new field of mathematics called visual mathematics has emerged. Especially for younger students, it is important to work with constructions and colours. In this way, students can better see how planes and three-dimensional shapes are formed and how formulas work. We are also used to using maps, graphs and charts on a daily basis to understand real-life problems and data-based decisions. Today, many students have a visual perception. They learn the topic best when they can see what is happening, and a non-visual approach can even hinder their efforts to solve the problem.

A good example of a visualization strategy for learning mathematics is the famous Königsberg "bridge walking" problem, which can be easily explained by creating a graph diagram as a visual representation of the situation.

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5.4. Explaining to others

Researches (Chi & Wylie, 2014; Simmons, 2019) show that by teaching others what we learn ourselves, something magical happens in our minds. We suddenly notice mistakes in our thinking. We have more creative insights. Our ideas become more convincing. We remember longer what we learn again. We see connections more effectively. We receive a lot of feedback, which in turn improves our knowledge. This unique magic rises from an interactive effect, illustrated by the modern learning pyramid (Simmons, 2019), which proves that we learn a substance best when we explain it clearly to others.

In math classes, special attention should be paid to those who speak, because there is a good saying: "he who speaks learns." As a successful example, the digital application TeachFX (2020) has been developed, which records the conversation time of teachers and students in the classroom, measuring student involvement and displaying feedback.

5.5. Associative Learning

The goal of mathematics training has always been to raise awareness. Learning with comprehension has been a major theme in mathematics education researches since at least the 1930s, and the question of what exactly mathematical comprehension means is not an easy answer (Hassler, 2016). The European Union-funded portal http://goerudio.pixel-online.org/ brings together experiences from European teachers with the aim of raising pupils' understanding of mathematics and supporting teachers with innovative ideas. And the awareness tool GoErudio (2020), developed in Latvia, which has received several awards for innovations, is a particularly effective support of the Education Foundation for mathematics training.

For example, to give students a better understanding of the Interval Method for Calculating Inequalities, mathematician and artist Roman Vitkowski on Goerudio.com offers associations with a swimmer (Figure 03) who dives underwater (negative values) and dives above water (positive values) at specific x values.

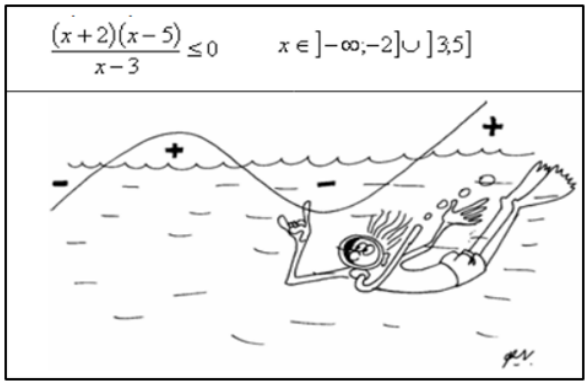

Figure 03. Interval method (goerudio.com)

5.6. Repetition and Strengthening

Repetition is a simple strategy that teachers can use to improve students mathematical skills. By repeating and reviewing previous formulas, theorems, lessons, and information, students are able to understand mathematics much more quickly. According to Ebbinghaus's oblivion curve (Chun & Heo, 2018), there is a strong correlation between memory and time (Figure 04). Usually, forgetting in the initial

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process happens very quickly, and only by repeating a substance or action do we consolidate knowledge for a longer period of time.

The human brain cannot be inactive. They want to learn all the time. We learn what we practice every day. Specific basic rules and activities in mathematics need to be strengthened through repetition so that students can move on to more in-depth learning later on. Repetition is the simplest tool (ReEd, 2020) that makes it easier for students to learn a topic without wasting time.

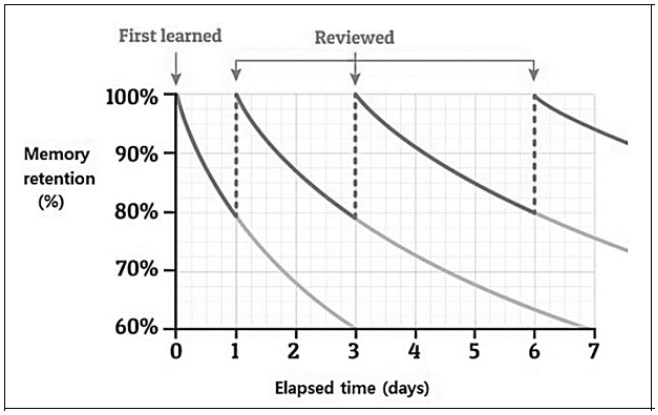

Figure 04. Ebbinghaus' forgetting curve and review cycle (Chun & Heo, 2018)

5.7. Blended Learning

Due to the Covid virus and the declaration of a state of emergency in the spring of 2020, most schools around the world switched to distance learning using the benefits of technologies. And it is now absolutely clear that in the future, in addition to traditional teaching methods, digital solutions will also stand, giving students a taste of modern education. Blended learning solutions (Edsys, 2020) will become increasingly popular, aiming to ensure optimal digital infrastructure requirements while preserving traditional learning resources. Mobile Technologies, Web Collaboration Tools, Virtual Reality, Augmented Reality, etc. will successfully complement face-to-face presentations, visual materials, paper templates, online meetings and group activities.

In the future, more and more new and unique mixed solutions will be created, such as printed textbooks related to interactive tasks and their assessment on a smartphone. A successful example is the interactive math simulations found on the platform https://phet.colorado.edu/en/simulations/category /math.

5.8. Real-World connections

The ability to relate mathematics to real life is a common goal of school mathematics curricula in many countries (MoNE, 2012; NCTM, 2000). According to the Turkish Curriculum for Secondary Schools, "developing students' mathematical skills and using these skills to solve real-life problems" are the two main aims of teaching mathematics (MoNE, 2012). Students often wonder if, when and how they will ever use mathematics in "real life" situations. The truth is that we use mathematics all the time! It is important when you need to build something or create a grocery store. Cooking is one of the most enjoyable and delicious ways to introduce students to mathematics. Mathematics also has many applications when

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traveling - from determining the amount of fuel required to planning a trip at a distance and time. From playing games to playing music, mathematics is very important to help students accurately adapt their creativity and turn dreams into reality. For example, in Latvia, the company Accenture, in cooperation with partners, launched a project in early 2020, showing the most interesting facets and applications of mathematics. Within this framework, mathematical tasks of various professions were created to sharpen the mind, which can be used very well in everyday mathematics lessons.

5.9. Humour as a method

It is very important to include humour in subjects such as mathematics, which is considered to be one of the most difficult to understand. Humour reduces tension and motivates learning better. A research (Ngussa & Mbuti, 2017) concluded that teachers who use humour in teaching are rated effective by the learners in terms of motivation, creation of engaging lessons and anxiety reduction. The teachers are also rated effective in terms of stimulation of thought and interest in students and fostering of a positive teacher-student relationship. The use of humour further creates a sense of friendship between the teacher and the learners; thus, learners are likely to like the teacher and the subject matter. Researchers (Abdi Ali et al., 2016) contend that if students like their teachers, they will start liking the subjects taught by them and be more attentive in the class. Researchers (Vijay & Phil, 2014) contend that "A strict teacher can be successful but a humorous teacher can be more successful." This suggests that mathematics teachers need to make us of humour as an instructional strategy to attract the attention of learners and increase interest for learning.

6. Findings

The described learning strategies provoke students to think and engage in the learning process actively, as well as correspond to a modern learning concept. The new field of neuro-education is currently in its beginnings, but many researches (Bidshahri, 2017; Wilson & Conyers, 2013; Witt & Baird, 2018) indicate that modern learning is interactive, authentic, situational, student-centred, personalized, collaborative, created on demand, complemented by technologies based on neuroscience discoveries. Modern learning creates interest and curiosity in students, encourages them to go deeper and repeat what is most important, creates pleasant emotions and an individual approach, requires critical thinking, project work and open problems.

6.1. Evaluation of effective learning strategies

The summary and evaluation of the eight strategies provided in Figure 05. will further help mathematics teachers to choose the most appropriate strategies for their teaching style in order to become a more effective mathematics teacher in general, which motivates students and improves attitudes in the long run.

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Strategy	Positive features through learning strategy	Impact on indexed desire
OPEN-ENDEDNESS STRATEGY	Encourages students to provide a variety of solutions; Promotes students' cooperation; Simpler and more complex answers are possible; Opportunities for students to show their knowledge more fully; Promotes feedback; Promotes logical thinking.	4., 10., 13., 14., 15., 16., 17., 19., 20., 22., 23.
VISUAL REPRESENTATION	Helps to describe a mathematical idea more clearly; A good tool for solving mathematical problems; Creates a deeper understanding of abstract concepts in mathematics; The learning process becomes engaging and creative; Research and new discoveries are encouraged.	4., 9., 13., 14., 18., 19., 21.
EXPLAINING TO OTHERS	Learning together and collaborating; Discussions between students are encouraged; Students try to understand the topic in order to explain it better to their classmates; Concentration increases; There is joy in being together and the result achieved together; Feedback is generated; New ideas emerge in the discussions; There is a growing sense of responsibility for one's contribution; Everyone becomes a personal trainer.	4., 10., 11., 15., 16., 17., 20.
ASSOCIATIVE LEARNING	Makes it easier for students to learn the subject; Creates an understanding of mathematics; Stimulates students' imagination; Allows teachers to explain the subject better	1., 4., 7., 14.
REPETITION AND STRENGTHENING	Knowledge is strengthened for a longer period of time; Mathematical skills are improved; Possibilities to learn the topic much easier and faster; There is a gradual transition to more in-depth training and more complex content.	3., 5., 10., 14., 16., 17., 20.
BLENDED LEARNING	Teaching methods more relevant to the needs of the digital society; A taste of modern education is given; Time resources for students and teachers are saved; The advantages of technologies are used; Interdisciplinary solutions are promoted; Innovative activities are encouraged; Independent repetition is encouraged.	4., 5., 6., 14., 16., 21.
REAL-WORLD CONNECTIONS	Mathematics is popularized; Different professions are understood; Research and brain sharpening are encouraged; The most interesting facets and applications of mathematics are shown; Career education is promoted.	2., 4., 12., 14.
HUMOUR AS A METHOD	Lessons are becoming more engaging; Anxiety is reduced; Students' interest and involvement is encouraged; The relationship between students and teachers is becoming more positive; The teacher becomes more successful; Perception of learning content is positively influenced; A positive atmosphere is created in the classroom; A creative process is maintained.	4., 8., 16.

Figure 05. Summary and evaluation of eight effective strategies

6.2. Support of AI

AI is increasingly taking over technology and education. AI's ability to store large amounts of data and implement large computing power makes it an increasingly popular tool in today's world. AI has so many positive features that its support in the future can complement or even replace many of the current successful learning strategies described in the previous chapter. In the research 2019 "The post-digital era is upon us. Are you ready for what`s next?" by Accenture in it is pointed out that technological developments are so rapid that in-depth research in areas such as teacher training, assessment of growth and educational changes it is still needed to develop new AI-based products.

AI has a really significant impact on the creation of educational services. According to researches (John, 2018; Karsenti, 2019; Kuprenko, 2020; Luckin, 2017; UNESCO, 2019), the main advantages of AI in education are the ability to: (1) improve students' learning outcomes and the quality of education; (2) to ensure equal and inclusive access for all; (3) personalize learning using algorithms that help students navigate along different paths of learning content; (4) create a better professional environment for teachers to work more with students with disabilities; (5) take over the day-to-day responsibilities of the teacher, freeing up teachers' time and allowing them to focus on leading students; (6) for teachers to work with virtual assistants to improve students' learning outcomes; (7) to help to determine each student's individual curricula and trajectories based on their strengths and weaknesses; (8) be an assessment tool, thus freeing up the teacher's time spent on assessment and homework assessment; (9) evaluate not only test answer options but also calculation tasks, essays, dictations and even oral narratives; (10) improve reaction rate through continuous training and repetition of the subject matter; (11) to provide students with an

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independent, autonomous and distance learning process; (12) easy to adjust training content; (13) to unite the class collective by performing exciting educational games; (14) promote group work; (15) to adapt not only to the appropriate rhythm and level of knowledge of each student, but also of each class; (16) offer a very large number of activities at the same time; (17) make important data-based decisions to ensure the quality of education; (18) provide immediate feedback to students, teachers and parents on student progress and achievement of learning objectives; (19) to promote an individual approach to each; (20) improve students' learning outcomes; (21) to promote lifelong learning processes regardless of place, time and level of knowledge; (22) to form and maintain discussion groups.

There are already many successful stories in the world where AI-based products are successfully used in education. For example (UNESCO, 2019), in China, digital education company Hujiang has developed image and voice recognition software that can understand students' facial expressions to provide online feedback. China has also set up an adaptive platform, Liulishuo, which can teach English to 600,000 students at a time, as well as a Superteacher platform, which can simultaneously answer questions from 500 million students preparing for the University's entrance exams. In Uruguay, an online adaptive learning solution called the Mathematical Adaptive Platform (PAM) has been developed, the content of which is adapted to the national mathematics curriculum. PAM provides personalized feedback according to each student's skill level, based on an analysis of the student's experience. PAM provides assistance to students through more than 25,000 differentiated tasks and 2,800 feedbacks to explain the solution to each task.

A successful story for many years is the platform "Mental Math" developed by the Estonian company Miksike (2020) to strengthen the basic mathematical calculations. In particular, the program provides a wide range of activities that assess and develop mathematical knowledge, offering students differentiated tasks with increasing difficulty. In this way, students train, compete at the global level, become more persistent and progress in their knowledge.

7. Conclusion

There is currently a competition between education and technology. At a time when the possibilities of Blockchains, AI and neuroscience are evolving, ancient training systems threaten the economic potential of the Fourth Industry (Accenture, 2019). It is irresponsible to continue using traditional teaching methods if many credible studies point to more effective teaching strategies. Researches in the new field of neuro-education (Bidshahri, 2017; Wilson & Conyers, 2013) emphasize that, in collaboration with AI, individual brain activity data can be used in the future to understand each student's strengths and weaknesses and make math learning much faster, deeper and more personalized.

In the future, effective learning strategies are needed to prevent rising unemployment and income inequality in the Fourth industry era, as student learning can be improved by:

- Positive attitude created by humour, interesting approaches, good attitude, awareness raising and real-life examples.
- Support possibilities provided by collaboration, feedback, good evaluation, repetition and reinforcement, one-to-one counselling and teaching others.
- Possibilities for technology to engage in social cooperation and active learning environment.

- Essential investment in human resources, technologies and infrastructure to transform the way we teach and learn.
- Understanding that effective learning is a social process where repetition, a positive role model of the teacher, active participation and solving open problems are especially effective.
- Continuous development of teachers to keep up with the latest research, re-evaluate professional experience and apply the most effective teaching strategy to each student.
- Essential support for teachers, especially teacher training, which promotes active and shared learning by students and fosters growth and innovation thinking for the economy of the future.

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