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Situation games to ease transition between abstract and real life mathematics for primary school student teachers*

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Abstract

With the accelerated development of science and innovation, as well as the invasion of digital systems there is a growing need for science teachers who can provide short, precise and clear explanations on scientific issues. In addition, it is essential for teachers to know how to use new systems, information technology and how to help their students in evaluating and sharing information responsibly. They need to become active data explorers who can plan for, acquire, manage, analyse, and infer from data. The goal is to use data to describe the world and answer puzzling questions while playing roles in different situations so students can playfully prepare for today's data-driven

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society. On the other hand the time of students and teachers is precious; hence, one of the teacher's crucial tasks is to find methods and techniques in order to motivate students to learn and to make the learning as effective as possible. The freedom in teaching enables teachers to develop an innovative learning environment and effective teaching techniques for students to work well together and be successful at learning. Our approach is to explore new forms of teaching and learning to allow students to think critically without relying on their teacher's answers. In this research, using methods that also improve communication skills in the form of situation games with the help of drama pedagogy and observing what makes the method more effective can help in productive innovation.

Keywords: mathematics education, innovative learning environment, primary teacher training, didactical methodology, situation games, drama pedagogy.

1. Introduction

The problem of low mathematical skills of students is caused by many reasons such as unsuitable teaching and learning environment, few teaching methods, negative attitude of pupils and parents towards mathematics, shortage of good quality teaching and learning materials, negative interaction between teachers and pupils to mention few (Michael, 2013).

All learners are different. However, most educational materials are the same for all. In terms of teaching methods, a teacher has plenty of great possibilities to use, learning environment arrangement, visual aids, etc. This freedom in teaching provides a good chance to use an enormous number of ideas in the classrooms (Boumová, 2008).

According to a report by Open University in 2017, ten innovations are already in currency but have not yet had a profound influence on education. A short list of these new pedagogies is: spaced learning, learners making science, open textbooks, people need to be able to evaluate and share information responsibly, intergroup empathy, immersive learning, student-led analytics, big-data inquiry, learning with internal values, humanistic knowledge-building communities (Ferguson, 2017).

2. Theoretical background

Since the time of Socrates, philosophers have questioned the purpose of education and they have proposed four answers. Education is intended to train people for employment, to develop good citizens, to socialise people within a community, and to develop happy, rounded individuals.

As Kenneth T. Henson claims, some teaching purposes such as understanding, knowledge transfer usually determines the methods to use; however, there never exists the best method for everything (Henson, 1980).

Mathematics can provide the necessary knowledge and skills to empower a person to process a mass of information every day. Students are required to learn a

considerable amount of complex and diverse mathematical knowledge accumulated during thousands of years. However, instead of expanding the curriculum another dimension such as the didactical point of view is to be considered and integrated into it. Students need to be engaged in activities encouraging learning and investigation. Carefully designed teaching methodology and entirely new organisations of tasks provide opportunities for students to develop their epistemic value (also Artigue, 2010, p. 467) and to take part in problem solving activities while learning how to apply their knowledge to real-life situations. In the present project, this means that students' work with the designed situations should be related to, and support, their work with theory and so facilitate the transition between abstract and real life mathematics.

One of the most important principles is gaining experience based on specific activity, using tools, and inserting games and playful activities in classroom lessons. The emphasis should be on understanding, on the process and on creating efficient learners rather than on the product (Carr, 2011).

The Hungarian endeavours characterised by names such as Zoltán Dienes and Tamás Varga were part of the worldwide education reform, but in many respects, they diverged from the dominant foreign trends. "According to Tamás Varga, young people are able to learn new topics if it is done playfully. Teaching tools were recommended for primary school teachers, for example, how to improve space-vision with the building game Babylon, or the Dienes-set for teaching number systems" (Reményi, 2007).

According to Jim Scrivener, the teacher's main role is to "help learning to happen," which means "involving" students in what is going on "by enabling them to work at their own speed, by not giving long explanations, by encouraging them to participate, talk, interact, do things, etc." (Scrivener, 2005).

Another vital aspect is context and purpose. This is supported by the opinion expressed by Jill and Charles Hadfield who claim, that activities which mirror real life situations and which have a goal, for example finding a rule, are "more interesting and motivating for the learners (Hadfield, 2003).

Significant changes are needed in the pedagogical support of the university curriculum, filling it with teaching methods providing the training of future specialists with the required comprehensive result. Modern education should focus on students' independent activities, the organisation of self-learning environments and experimental and practical training that encourage students' interest in the profession, promote the efficient acquisition of training materials, form patterns of conduct, provide high motivation, strengthen knowledge, team spirit and freedom of expression, and most importantly, contribute to the complex competence of future specialists (Nadezhda, 2014).

3. Framework of the research

It has long been known that we learn facts better in a series of short sections of the education material with gaps between them, rather than in a long teaching session

such as a lecture. Situation games can provide gaps necessary for successful spaced learning.

Learners need the skills and knowledge to solve problems, evaluate evidence and make sense of data encountered in a complex and constantly changing world. A strong understanding of Science, Technology, Engineering, Arts and Mathematics (STEAM) topics can develop these skills. These changes can be achieved through participation and contribution to science activities in different situations that are personally relevant, help critical thinking and reflection. In situation games, learners can experience how science is made and can enhance their content knowledge.

In situation games, students from different backgrounds interact with each other. This means that skills such as communication, teamwork and empathy are important. Drama pedagogy provides the theoretical framework of situations used for educational purposes. Activities designed to promote intergroup empathy can provide effective responses and help to reduce tensions.

Learning based on experience in learning situations and exploration can be intensified through immersion. It can enable people to experience a situation as if they were there, applying their knowledge to solve a problem or practice a skill. The learning comes from integrating vision, sound and movement. Immersion requires learners to act out scenarios or take part in investigations, pretending to be actors to stimulate reality.

Learning should be rooted in students' own needs and interests and shaped by their internal values. However, students need to learn a set of external values from the national curriculum. We have made efforts to design and develop situations that can meet this challenge. The main approach is to offer students a choice of what role they can play and how they learn. At the same time, it equips them with means to develop appropriate skills and way of thinking in order to support their learning.

Another goal of situation games is to help students become open to experience, creative and self-directed. This is a person centred approach. The curriculum contains collective knowledge of a community. This is an idea-centred approach. We focus on combining the two approaches. Research shows that students who can find a balance between the two approaches develop their knowledge in integrated and transformative ways.

Through a discussion of the results of the present action research, we can share some interesting first results with practicing primary school student teachers.

The new direction in curriculum development is to link methodology of teaching mathematics to subjects taught in primary schools. In this way, students can gain practical knowledge in their future teaching job and they see what mathematics topics are necessary to teach and how to teach those in primary schools.

The first author teaches mostly mathematics and methodology in a teacher training college (now part of a teacher training university) since 2004 in a small town Sárospatak, in Hungary. In 2017 she became responsible for the practical training of teaching students in the second and third year. Therefore the first author carried out research work with students teaching mathematics at II. Rákóczi

Ferenc elementary training school collecting potentials and disadvantages of situation games in teaching. Data were collected by student questionnaires.

The second author teaches mathematics combined with methodology at Eszterházy Károly University in Eger. In this experiment she taught Functions, elements of analysis for students in the second year. In the previous terms students did not use situation games during their mathematics lessons. However, they used them when they were learning Functions, elements of analysis. We compare students' average results at the end of the first three terms with those at the end of the last term.

The third author is the inventor of the new communication methods closely related to situation games, such as the MATHeatre method and the MATHFactor method and recently the SCIENCEtheatre and the SCIENCEFactor (Makrides, 2017). He is also the founder of the new THALES programme for developing analytical skills in pupils of ages 8-15 through a short programme that involved word problems relating to real life situation, mathematics communication and memory development actions. The later includes also the new THALES^{TM} testing for competence (C test) and for mathematical ability (M test).

All three of us trust in applying innovative teaching methods building on pupils' and university students' activities. Love of mathematics and interest motivate learning more than any other factor. It is important to differentiate in the teaching process, to take into account differences of individuals, to let make mistakes without punishment, to play games at home and in the lessons for pedagogical purposes.

4. Findings and interpretations

Our aim is to educate university students to become proficient learners and later on teachers. These skills include understanding the nature of knowledge, assessing the validity of claims, and forming sound arguments. They include the development of reliable processes and strategies for making sense of the world – such as the scientific method. They include the ability to empathise with others and to judge the merit of different perspectives and narratives. Recent research in neuroscience has uncovered the detail of how we produce long-term memories. A study of spaced learning shows a significant increase in learning compared to a typical lesson. (Ferguson, 2017). This has led us to design a similar teaching method of spaced repetition that occurs in the following order for university students: (1) the lesson begins with a revision of 5 minutes (2) the teacher gives information for 20 minutes; (3) students take a break of 10 minutes to participate in a connected practical activity such as playing situation games, modelling; (4) students are asked to recall key information for 10 minutes with the help of situations where they applied their new knowledge. The first two authors applied situation games during their lessons for university students and built on students' active participation in problem solving activities. Students acted a certain problem in a situation and then solved it by creating a mathematical model. The principles of teaching management include the methodological diversity, the encouragement of group and individual work instead

of the previously dominating frontal form of work.

Some examples of problems solved with the help of situation games are shown below. We used problems of elementary level to show university students how to make learning mathematics more experimental, effective and to raise their pupils' motivation level. We tried to find less abstract examples being useful for future elementary school teachers to apply in their teaching practice. The first problem concerns sets and set operations. Function is involved in the second and geometric sequences in the third.

Example 1

For the situation game we choose five students. Four will be shopkeepers and one of them will be the customer. There are four shops a bookshop, a music shop, a shoe shop and a bicycle shop. The customer wants to buy something from each of these shops. The customer lives in a small village and needs to travel to a neighbouring town to buy these things in those shops. The customer knows when they are open and he/she needs to find when all four shops are open at the same time and to find out how much time he/she has to get to each of these shops. The shopkeepers will tell the customer the opening hours of the four shops and what they sell and then they play their roles:

1. 8.00–14.30
2. 9.00–15.30
3. 9.30–16.30
4. 8.00–12.00 and 13.00–17.30

This task found in a textbook has been transformed into a situation game.

Example 2

Two students want to go on a treasure hunt tour. They got a small map with the ratio of the zoom and they need to find out the distances in reality. They calculate that if they leave at 9 o'clock in the morning they need to walk 3 hours in a forest to reach a view point 10 km from the starting point. They have a rest for an hour and have lunch. After lunch they walk 18 km further for another 4 hours, and they get to a tree where they need to dig to find the treasure. The other students are drawing the graph of the trip as a function of time.

Example 3

The following problems can be solved in groups. Some students are chosen to be bank managers giving offers to a student who has money and wants to find the most advantageous investment offer. Geometric sequences can be practiced with these real world problems. If we want to challenge students we can even ask them

to find the current best investment. They can use the internet during problem solving. In this way everybody who has some capital is interested to find the best offer to gain as much money as possible.

1. Which investment is the most advantageous, A, B or C if we want to put a given amount of money to gain interest in a bank,

   A: at 4% interest, compounded annually at the end of 3 years;

   B: at 12% simple interest at the end of a year;

   C: at 6% interest, compounded annually at the end of 2 years?

   Solution:

   In the case A you need to multiply the given amount of money by 1.04^3 which is approximately 1.125.
   In the case B: the same amount is multiplied by 1.12.
   In the case C: you need to multiply the same amount of money by 1.06^2 which is approximately 1.124.
   Therefore the most advantageous investment is in the case A.

2. We have 1,000,000 Ft and two investment opportunities to invest our capital for five years:

   A: at 10% interest compounded annually;

   B: at a simple interest gaining 120,000 Ft annually.

   Is the investment B more advantageous?

   Solution:

   In the case A $1{,}000{,}000 \cdot 1.1^5 = 1{,}610{,}510$ Ft is the returned amount.
   In the case B $1{,}000{,}000 + 120{,}000 \cdot 5 = 1{,}600{,}000$ Ft. Hence the statement is false, B is not more advantageous than A.

3. Which investment is more advantageous A or B if we place a given amount of money in a bank.

   A: at 4% interest compounded annually in the first 3 years then the grown amount is put at 6% interest compounded annually at the end of the next 3 years;

   B: at 5% interest compounded annually in 6 years;

   C: at 6% interest compounded annually in the first 3 years then the grown amount is put at 4% interest compounded annually in the next 3 years?

   Solution: B

Figure 1 presents mathematics result of the same group of students in the last 2 years. The second author was their teacher in the last term. 17 students took part in the research and they learnt Thinking methods (Sets, logic and combinatory), Algebra and number theory, Geometry, Functions, elements of analysis.

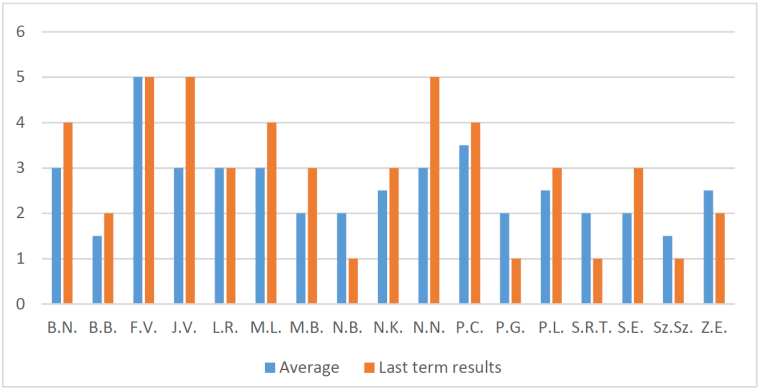

Figure 1: Results of students in Mathematics

Figure 2 shows that 59% of students improved their results at mathematics. Hence, most students progressed during the teaching experiment. Seeing these results we wanted to find out why the results of 29% of students got worse. In order to answer this question we asked students to fill in a questionnaire.

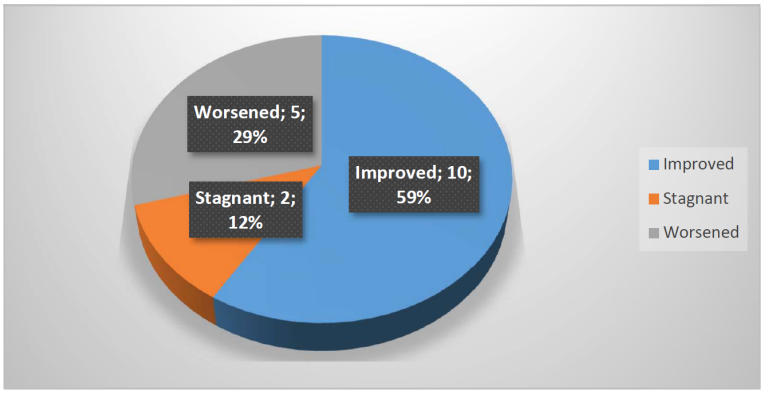

Figure 2: Number of students

5. Student questionnaire

It is not surprising that students with an overall low performance will not be considerably improved. Our aim was not to make easy tasks but to include tasks

in the form of situation games. The easier alternative, structured interviews based on selected topics, had to be given up because there were not a sufficient number of volunteers (exam period followed the term). However, interesting evidence is found in student questionnaires, done in writing during the exam period and with student replies being anonymous. Three questions concerned the lessons where situation games were used as a teaching method during the term. In the first, students were asked if they improved their results in the last term. Then in the second and third questions, students were asked to indicate reasons for the changes in their results and to comment how situation games contributed to their progress. Students could give open field responses. As many as 17 students have responded; they cannot be considered – representative but they represent strong opinion on the matter. Here are some examples of the students' responses (translated from Hungarian):

"My results did not improve. Situation games make lessons fun and interactive. I intend to use this method in the future."

"My results improved as I am more motivated to get a scholarship. I can use situation games in my future teaching practice."

"My results improved as I attended lessons more often. Situation games made mathematics more understandable. As the group is small we had more time to talk about what we did not understand."

"My results improved. Situation games involved us more into the topic. Mathematics makes much more sense, it we are playing an everyday situation."

"My results did not improve, however, I liked situation games. I find them useful and funny. The curriculum was processed differently and not with the usual boring methods."

"My results improved. We could learn Mathematics while playing and having a good time and everything was more understandable."

"My results did not get better, however, I found situation games very useful. Not only the numeracy skills, but other important competences like problem solving in real life situations can be improved."

The first author collected benefits and disadvantages of the method situation games from students in their third year of training performing teaching in a practicing primary school. In the first term the method of situation games was not focused on, however, it was shown to students via videos on the internet. In the second term students were asked to write lesson plans containing at least one mathematics problem to solve with situation games. Most students used this method during their teaching practice at the elementary practicing school during this research. There were two questions on the questionnaires as follows.

1. What are the benefits of the method situation games?

2. What are the disadvantages of it?

Here are some examples of the comments of 15 students (translated from Hungarian):

Benefits	**Disadvantages**
Situation games make lessons more enjoyable for pupils. This method makes mathematics more practical, less abstract. Situation games help the learner to understand and memorise concepts. Pupils can have practical life education. Thus, more competence areas can be developed.	It is time consuming and requires more preparation, a deeper reflection on the part of the teacher.
It is fun and easy to build team spirit. It helps to overcome shyness. It helps to learn how to share tasks and to prepare for real life. It teaches behavioural rules and classmates get to know each other better.	Good planning is needed.
It improves logical thinking and problem solving strategies. It helps socialisation. With experience-based situation games it is easier to gain knowledge.	Shy pupils find it more difficult to play rules and show themselves.
Attention-grabbing, interesting, and fun for the students. Furthermore, many interesting things can be built in the lesson (fairy tale stories, animals, etc.)	it requires lots of extra work, imagination and time. I do not see a lot of disadvantages in it.
Students love to play. They are actively learn and not just passively listen to the teacher. The teacher can differentiate while giving problems or choosing rules for students to play. A game can be designed for several problems or for different topics in the curriculum. A concept can be easily recalled with the game.	The success of situation games cannot be predicted for certain (students can argue about the rules or they do not understand the problem).
Students who never liked mathematics can develop a positive attitude toward mathematics.	I do not think that situation games would be a disadvantage, perhaps certain situation games require more space than we have in the classroom.
With life-like situations it is an extremely effective element of the lesson.	

Table 1

6. Concluding remarks

This paper contributes to our understanding of how difficult it is to master mathematics concepts, problem solving strategies and methodology for students to become successful primary school teachers. Reasons for this difficulty are cited in the first two sections.

In today's education, the knowledge-centred approach is still dominant, often lacking a system approach, real-life applications. In different situations, students interact with a real or simulated world to support their learning process. Their mind and body work together so that physical and mental activities reinforce learning. In a classroom or lecture theatre, the context enables students to learn from experience. By interpreting new information in the context of where and when it occurs and relating it to what we already learnt, students come to understand its relevance and meaning.

Situation games can be played formally or informally. An effective method is for a teacher to propose a question in the classroom, then for learners to explore that question at home or on a field trip collecting information, then share their findings back in the class to produce individual or group answers. Learning in informal settings can link educational content with everyday life.

Students can advance their understanding of science and mathematics by arguing in ways similar to professional scientists and mathematicians in different situations with educational purposes. Argumentation helps students attend to contrasting ideas, which can deepen their learning.

Incidental learning is unplanned or unintentional learning. It may occur while carrying out an activity that is seemingly unrelated to what is learned. Situation games provide many opportunities for incidental learning.

Another advantage of teaching in the form of situation games is to provide time for teachers to observe their students. Eye tracking and facial recognition help teachers in analysing how students learn. One thing is certain students are hungry for wisdom but they need to see how the educational content is benefit for them. If students are lacking the content they are about to learn how it would hurt their future success? The better a student is at Mathematics the better they'll be able to solve problems of everyday life or to invest their capital, create innovative businesses and reach their aims.

During role-playing games students can collect data about players' actions and strategies in order to present new challenges. This idea of applying knowledge in a simulated learning environment is now one of the 10 innovative learning strategies for modern pedagogy.

Results of our research show that mathematical knowledge of 59% of students has improved and even those students whose results got worse or remained stagnant find the innovative method 'situation games' very useful. We offered modern teaching methods developing students' critical thinking, problem solving and decision-making skills. However, repetition and memorisation of information to educate students cannot be avoided in today's education. As with most things, it

is all about balance. We need to understand when different methods work best and when it is right to try new and innovative approaches. The needs and work of students have to be studied more intensively than we were able to do it in this study.

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