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Can gamification in physics lesson improve student's motivation and problem solving-skills?

Teachers as Researchers: Improving Classroom Practice through Action Research

Bojana Oreb | May 2022

Introduction

- I’m physics teacher in the upper secondary school Gymnasia Antuna Vrančića from Šibenik, Croatia. I teach students of different programme from 9th to 12th grade.
- The action research was conducted in the 10th grade of classical programme.
- In this class there are 21 students (8 male and 13 female students), most of whom have lower academic results and a general lack of interest in learning natural science subjects. Physics is not an exception.

Introduction

- Classroom is equipped with the interactive smartboard; students are allowed to carry mobile phones to school and use them in class for educational purposes.
- The physics cabinet is also equipped with the necessary equipment to perform various experiments.
- All material preconditions in the school for achieving good academic results are provided.

Introduction

- Through this research, the aim was to examine whether a persistent change in teaching method can improve students' motivation for learning and, consequently, problem-solving skills.
- The application of gamification in teaching was chosen as a main learning method.
- Certainly, it cannot be applied independently without being intertwined with various other forms of learning such as a group work or teamwork, inquiry-based learning, BYOD method and similar.

Review of the Literature

- Gamification is a method of implementing a game-like elements and processes in non-game context. Some elements of gamification could be a point scoring, certificates, peer competition, teamwork, score tables to drive engagement and help students assimilate new information and assess their knowledge (Mirzoyan, 2021).
- There are numerous articles that deal with the positive connection between the application of gamification and the increased motivation and engagement of students (Lee & Hammer, 2011; Alsawaier, 2018).

Review of the Literature

- On the other hand, gamification should consider a meaningful emergent experience that enables game elements like points and badges to support a sense of competence and autonomy in users (Dahlstrøm, 2017).
- Otherwise we risk to establish a negative connection between tangible rewards and intrinsic motivation (Deci, Koestner & Ryan, 1999).

Review of the Literature

- Problem-solving skill is one of the most important 21st century skills (Md. Mehadi, 2019).
- In physics students solve various problems applying different strategies (Muratović, 2015) which mainly depends on phase of the lesson or what we want students to achieve.
- Just as it is important to practice the application of physical laws in tasks and to develop procedural knowledge, so it is important to develop higher cognitive levels by solving problems like finding solutions to open-ended questions about phenomena that students have not yet addressed during class.

Intervention

- Considering the benefits of gamification in teaching and the importance of developing problem-solving skills in physics, a teaching was performed using different elements of gamification in the selected class.
- Student were awarded with pluses (like points) for the successful completion of the activities. They were solving tasks or problems in groups or in pairs. The members of the group changed each class hour so that the better students and those who collaborated with them in the group would not gain an unattainable advantage and discourage the other students. At the end of the research a student with the most pluses received the highest grade.

Intervention

- In our virtual Google Classroom, a leaderboard was published so students could check their score anytime.
- Some of the activities had integrated certificates of excellence for the students when they successfully finished them.
- Tasks, demonstration of physics phenomena or problem they needed to solve was given through QR codes or presented using digital tools like Genially or Canva designed as a game – like an Escape room game or a puzzle.
- Students used their mobile phones or school tablets for most of the activities.

Implementation of the intervention

- Teacher introduced the students to action research and the changes that will be implemented in lessons in the next period.
- During active research period from March 15th until April 15th we had four lessons per 80 minutes for implementation of the intervention.
- In the first lesson, after lecture introduction, students were separated in groups of three to solve various tasks which they accessed by scanning QR codes. Each group member of the one which solved the tasks first and correct, was rewarded with pluses on leader board (**Figure 1**) and in a class book.

Implementation of the intervention

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Figure 1 Leader board

Implementation of the intervention

- In the second lesson, students discussed within a group about few real-world problems in which violation of the first and second law of thermodynamics were hidden. Problems and student's solutions/explanations were written in a table.
- Then each group presented their conclusions to the rest of the class. Students used a rubric for peer-evaluation of explanations. The group which got the best feedback was awarded with pluses.

Implementation of the intervention

- Second activity this day was group work to repeat the content, systematize knowledge, and practice the task-solving procedure.
- This time tasks were given to students through the Escape room game created in Genially tool. At the end of the game students were awarded with certificate of excellence and pluses. (**Figure 2**)

Implementation of the intervention

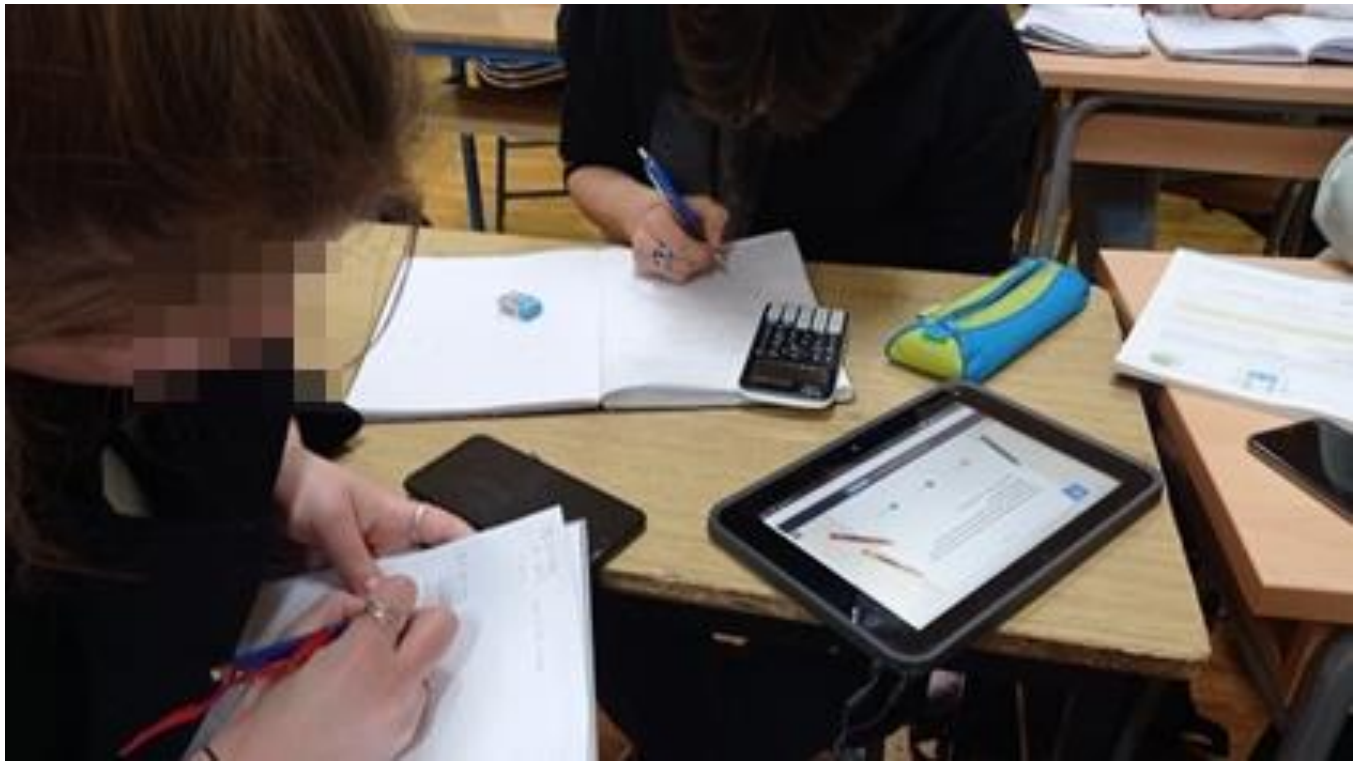

Figure 2 Students are solving an Escape Room game

Implementation of the intervention

- During the third lesson students watched in groups a pre-recorded experiments showing various electrostatic phenomenon. Videos were given via QR codes in a working sheet which they accessed with mobile phones.
- In the same working sheet, there were also a few questions which guided students through observation.
- After each group completed a task and explained their findings to the rest of the class, a teacher introduced an unfamiliar terms and physical phenomenon.

Implementation of the intervention

- At the end of the lesson, students got small papers with correct explanations (answers) on questions which they had to put on the right field in a working sheet.
- The group which solved the first (as a puzzle), got rewarded with pluses.

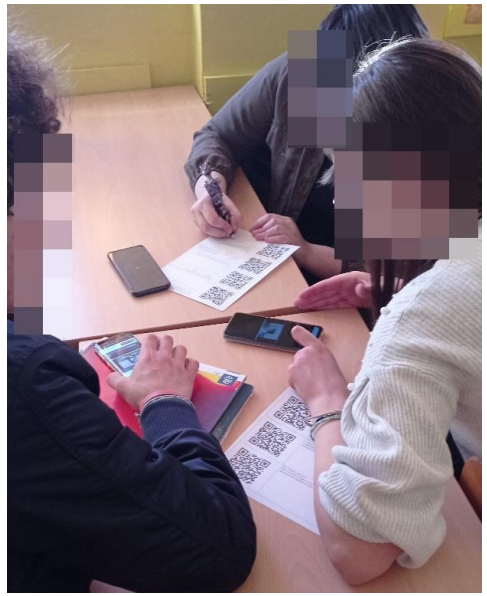

Figure 3 Students are watching experiments and answering questions

Implementation of the intervention

- In the last lesson students explored Coulomb’s Law (**Figure 4**).
- They worked in pairs and used a (online) Phet simulation to discover how electric force depends on product of electric charges and their distance.
- Three pairs who finished the first got pluses.
- After the teacher introduced the Coulomb's law, students applied a law in solving the tasks. They worked individually.
- This time each student who solved any task correctly got a plus.

Implementation of the intervention

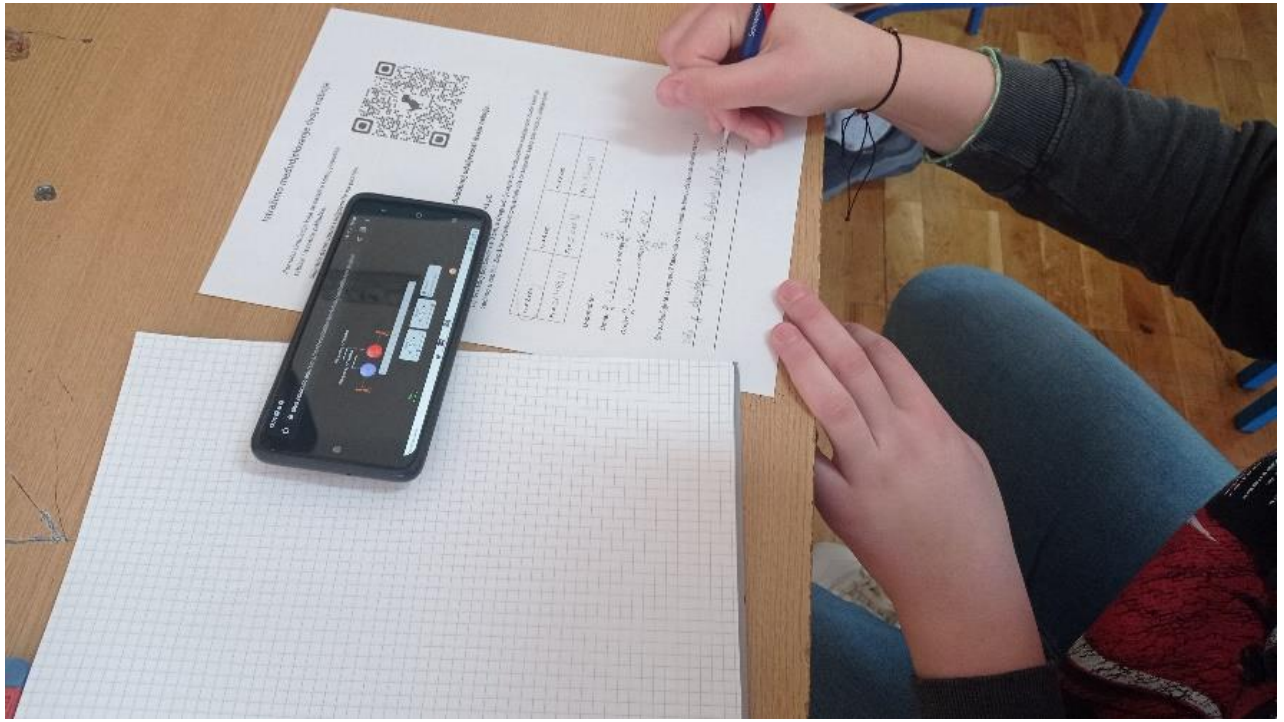

Figure 4 Student explores Coulomb's Law

Data collection

- Since this action research explored impact of gamification on students' motivation and consequently student's problem-solving skills, a mixed data collection methods were used – both **qualitative** and **quantitative**.
- The reason for this is to gain objective and measurable data for comparison between them as well as with teachers' observations and students' claims.

Data collection

- **Before the action research** started students were **questioned** about many aspects of the physics lessons like asked about their opinion on teaching, whether they find physics lessons interesting, what we can do to improve lessons, especially their engagement, motivation and about teacher's attitude towards students.
- Post research survey wasn’t conducted since students were observed by the teacher during each lesson and evaluated after, which gave us enough data to track efficiency, motivation, and students’ achievement.

Data collection

- During action research, after each lesson, **students were surveyed** about the lesson activities, their motivation to complete an activity and what will motivate them to be more engaged in solving the tasks, using Google Forms.
- The teacher kept **the diary** with recorded observations collected during the lesson, students' reactions, remarks and comments on various activities and their achievement especially in solving the tasks.

Data collection

- Also, students' skills to solve problems and numerical tasks **were assessed** before and after research and their achievements was compared with the results of another classroom where gamification wasn't applied.
- **Control group** has 23 students where students generally have better achievement and grades. This comparison can give us some insights into student's achievements and efficiency of gamification, but it should be systematically and thoroughly assessed.

Results

- The following graph shows students' answers in pre-research survey on question what they would like to have more in lessons to make them more motivated and engaged. Students could choose more than one answer.

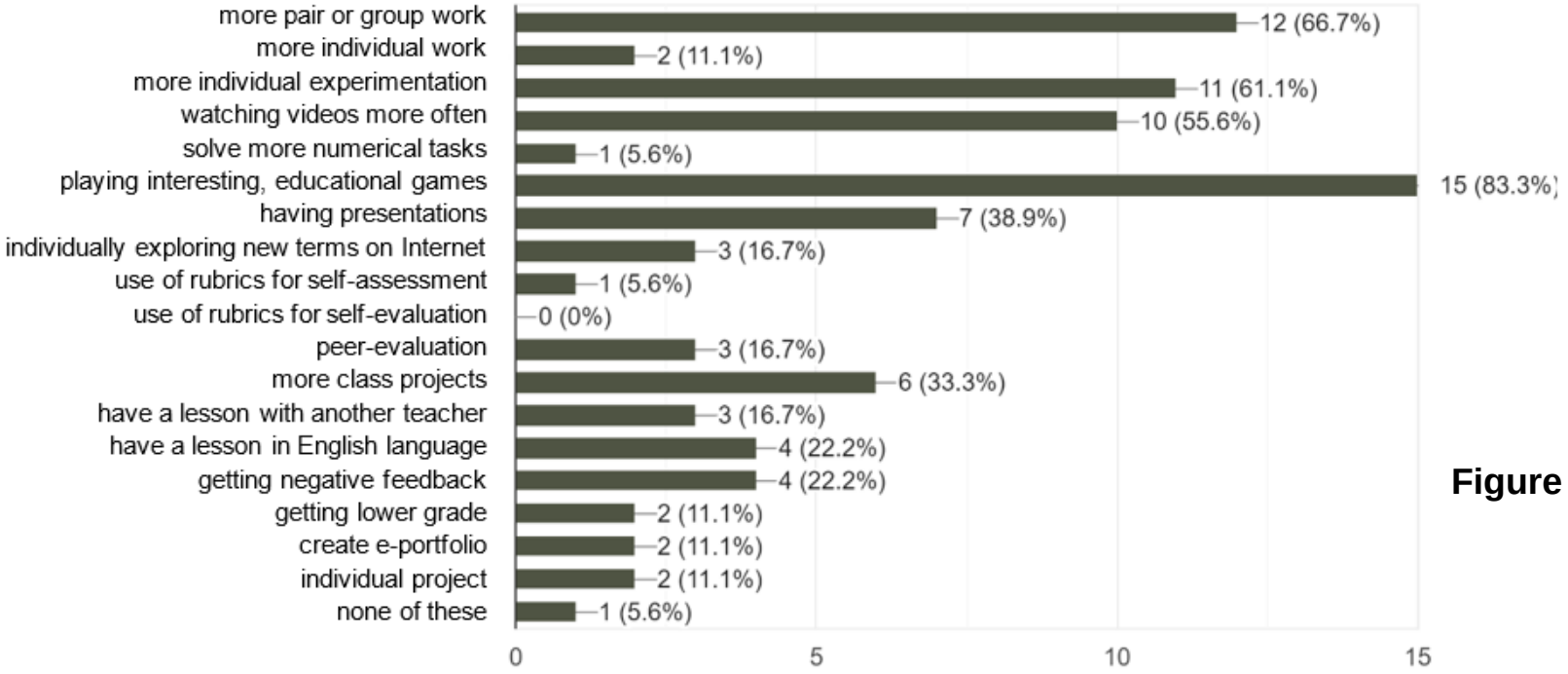

Figure 5 Students' answers on question what would motivate them more in lessons.

Erasmus+

Results

- As seen in a **Figure 5**, most of the students, 83,3%, said that more interesting, educational games would motivate them and 66,7% would like to have more pair and group work. Similar percentage of students wants to have more individual experimentation and video watching.
- Those answers were guidelines about what could have the most impact on students' motivations and achievements during action research.

Results

- After the gamification elements were implemented in the first lessons, obtained students answers are shown on **Figure 6**. Students chose to what extent they agreed with the statement where 1 means "totally disagree", and 5 stands for "totally agree".

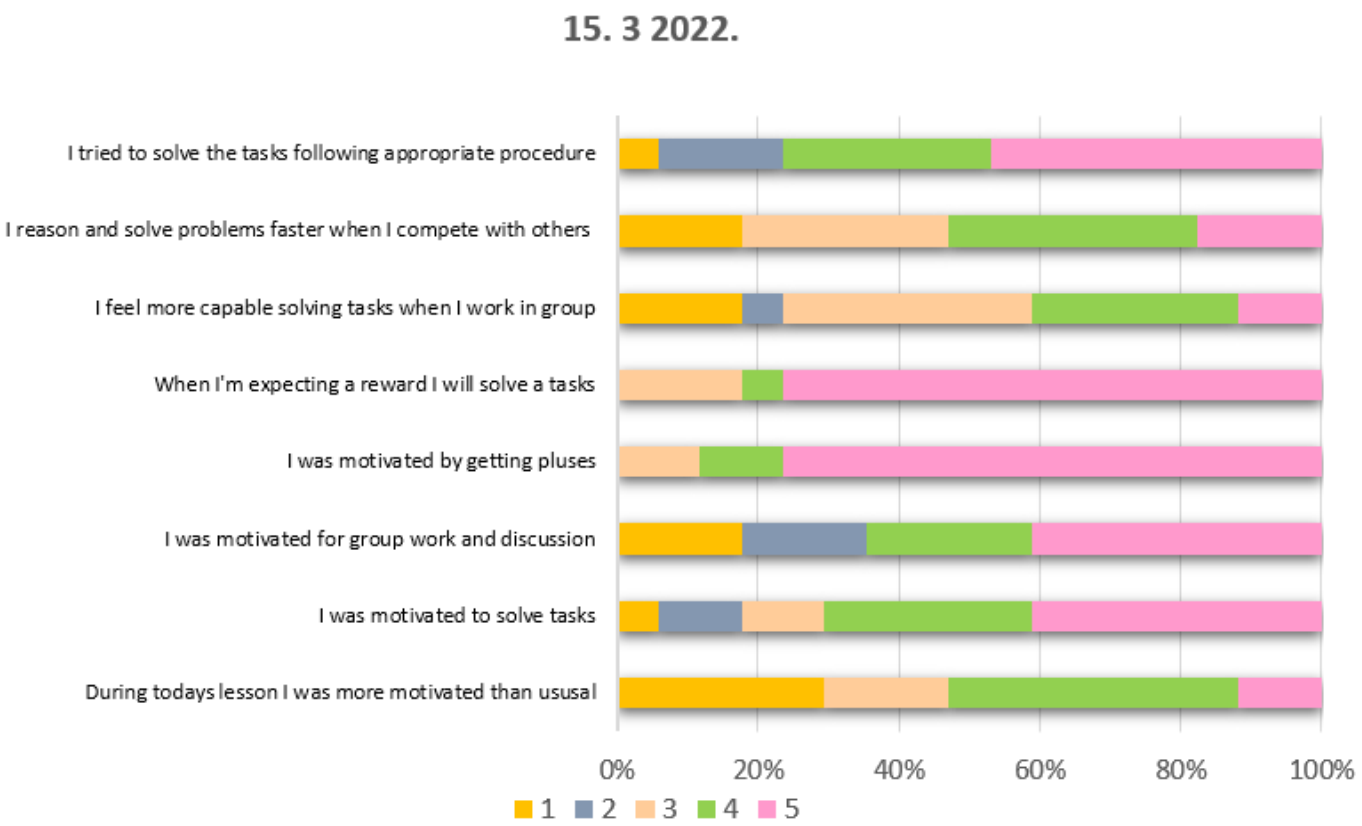

Figure 6 Students' answers after first gamified lesson.

Results

- As seen in a **Figure 6**, around 50% of students (totally agree and agree) said they were more motivated than usual and around 70% were motivated to solve a task. Getting pluses motivated more than 80% of students. Yet around 30% of students haven't reported increase in their motivation.
- According to teachers' observations, girls have shown more responsibility and motivation. Two groups were incompatible (never worked together before) and less engaged but one group of students with lower achievements did significant improvement and finished the tasks the second. The group with the best student finished the tasks first. Both groups were awarded with pluses.

Results

- Answers after second lesson were somewhat different as seen in **Figure 7**. Their motivation dropped by 10% to 20%. It is worth mentioning that this time we had lessons in the afternoon shift. Yet, getting rewards (pluses) still had great impact.

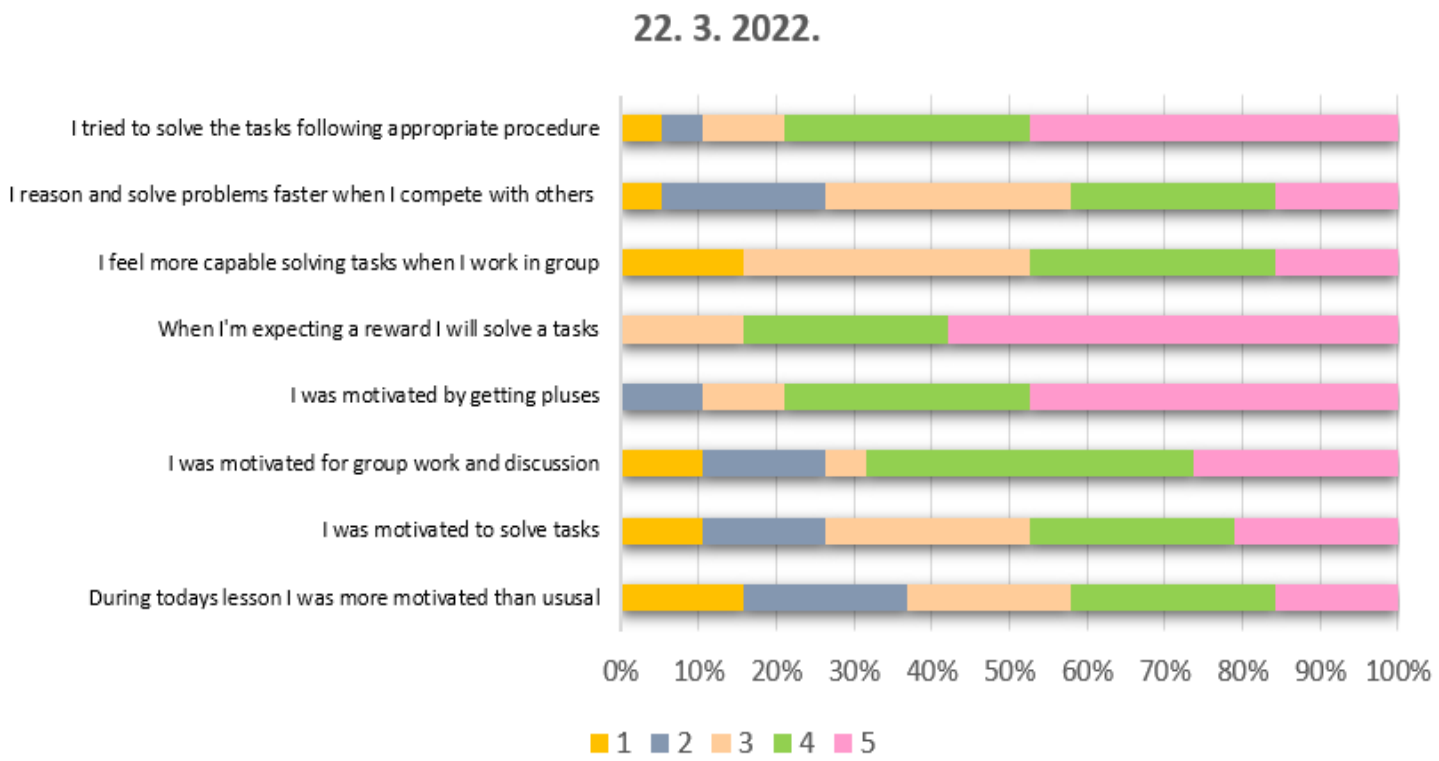

Figure 7 Students' answers after second gamified lesson.

Results

- Students were very active in group discussion, interested in listening and evaluating others group answers, way more than during tasks solving.
- Many of them commented that they liked the Escape room game.
- Students who usually have difficulties in solving tasks had them this time as well.

Results

- The third lesson (**Figure 8**) with inquiry-based learning and gamification once again showed that two-thirds of students were motivated more than usual especially if they expect an external reward for solving a task.
- In the conversation, the students stated that they liked the experiments as much as getting the pluses.

Results

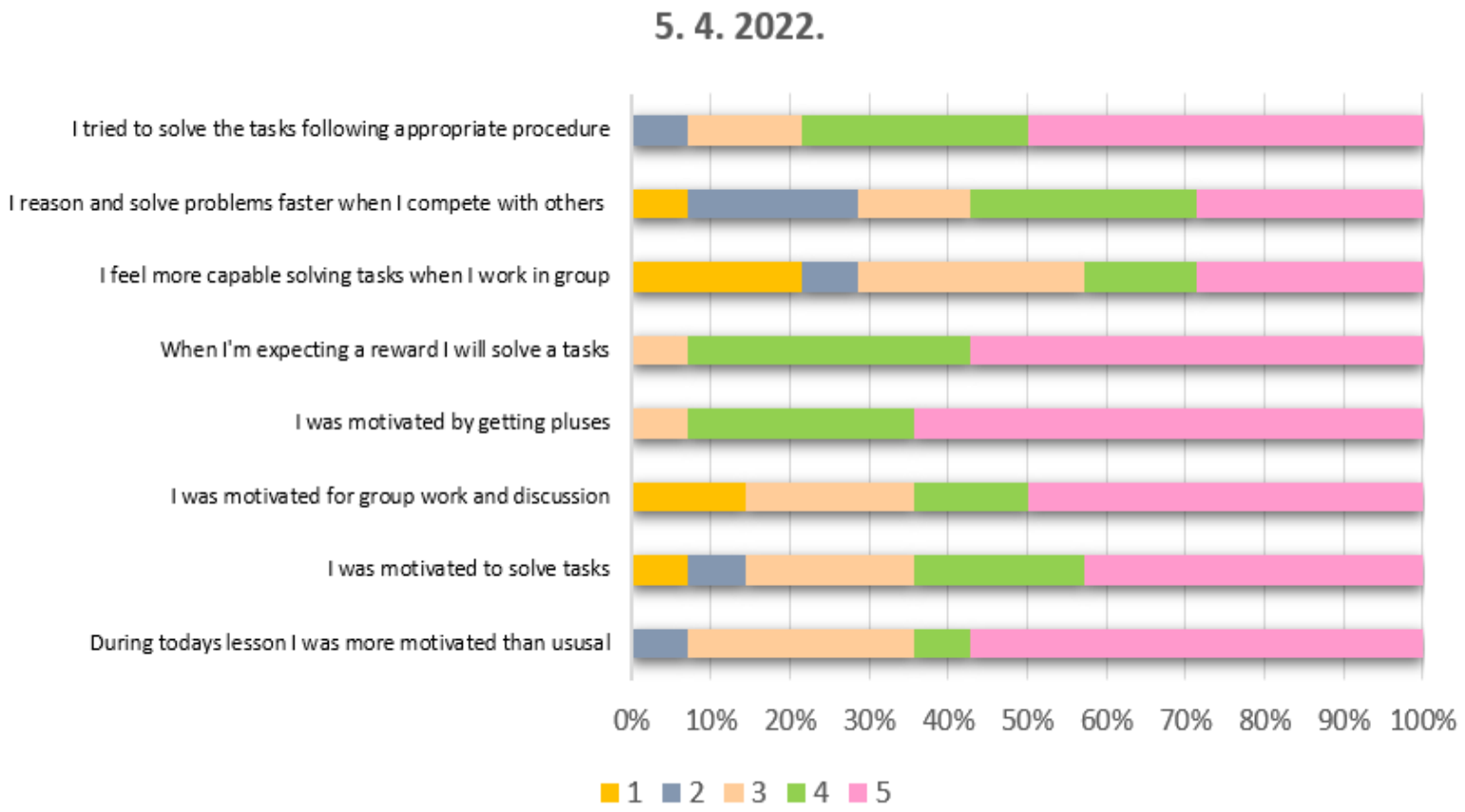

Figure 8 Students' answers after third gamified lesson.

Results

- In the last lesson with gamification elements all students were awarded with pluses for completing any task.
- This decision removed competitive element which didn’t show any significance in students’ motivation which is confirmed by similar distributions of student’s agreement on claim ‘’I reason and solve problems faster when I compete with others’’.
- Consequently, this affected that all students reported motivation to solve a tasks as seen on **Figure 9**. All students solved at least one task.

Results

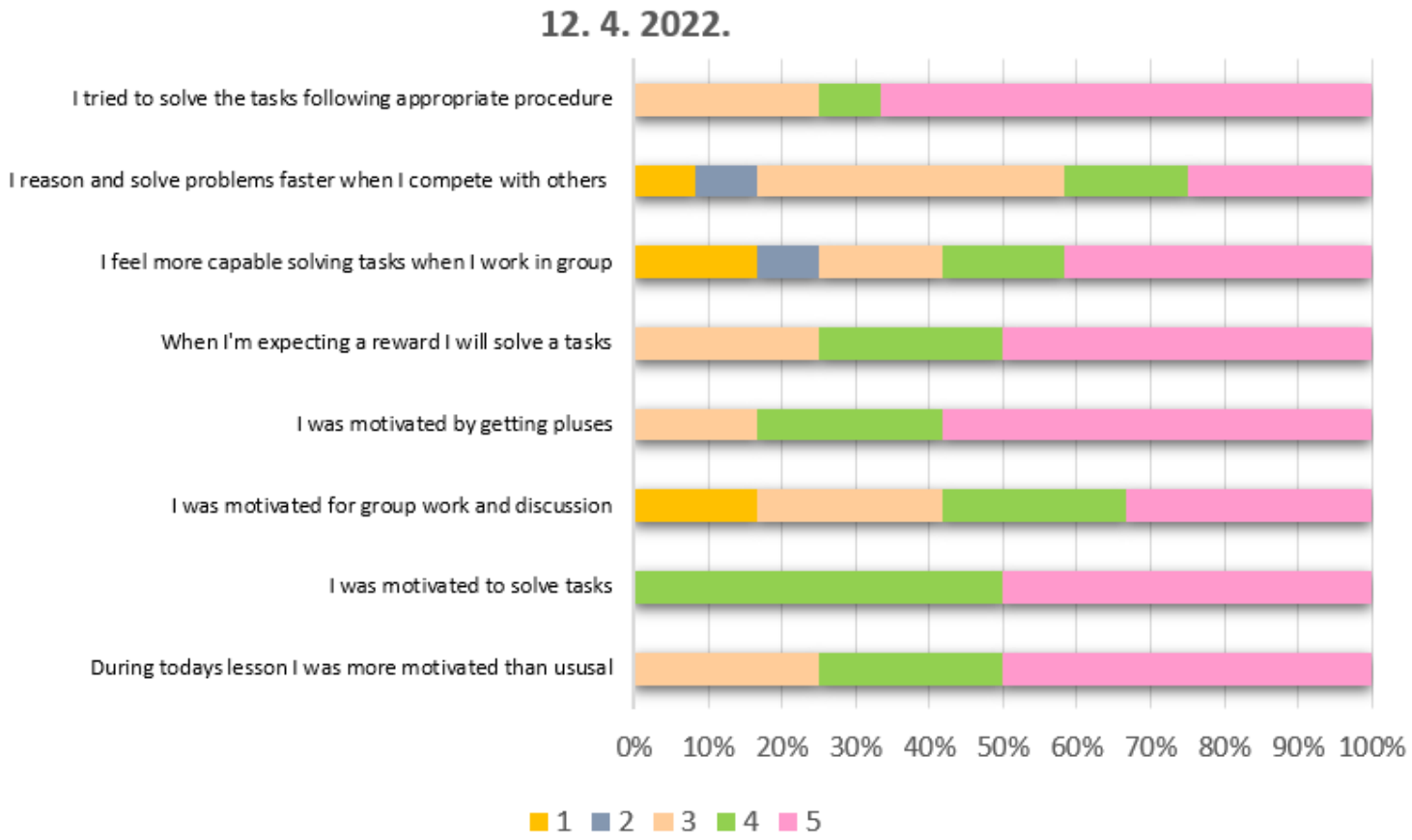

Figure 9 Students' answers after fourth gamified lesson.

Results

- Comparing students answers after all four lessons it is clear that around 20% of students weren't motivated more than usual.
- We can assume that this is the percentage of students who are always intrinsically motivated (as the student with best achievement and grades in class said) and those who aren't motivated at all. But this assumption should be investigated further.

Results

- The following **Table 1** shows students' achievement in assessment before and after gamification was implemented.
- Also, table shows comparison of achievement between two classes – the one we implemented gamification and the one in which the teaching/learning took place as usual.
- The assessments considered the student's ability to solve common physics tasks following the right procedure and apply physical laws to new problem situations.

Results

Table 1 Comparison of students' achievement in solving tasks

	Pre–research summative assesment		Post–research summative assesment	
achievement/ number of students	tested group	control group	tested group	control group
90% - 100%	1	1	2	3
75% - 89%	1	4	2	4
60% - 74%	7	9	5	6
45% - 59%	6	6	5	6
0% - 44%	6	3	7	4
average percentage	51,9%	61,0%	52,2%	61,5%

Note: the distribution of percentages in the left column corresponds to the usual range of grades

Results

- The higher the percentage, the higher students' task-solving efficiency.
- As seen in **Table 1**, both classes have slightly better achievements in the second assessment.
- There is no an indication that gamification method has contributed to a more successful problem-solving in students.

Conclusions

- Aim of this action research was to determine the impact of gamification in lessons on students' motivation, engagement and problem-solving skills.
- Students' opinions and attitudes were continually surveyed after gamified lesson.
- During each lesson, a teacher observed students in their work, collected their comments, remarks and reflections in diary.
- Gamification has been chosen since pre-research survey showed that students of this particular class would like to have more educative games in lessons.

Conclusions

- Also, research has shown a positive connection between gamification and students' motivation as Alsawaier has presented in his work (2018).
- To examine whether gamification elements as points awards, certificates, leader board consequently affected students' problem-solving skills, we compared assessment results of this tested class and control class before and after intervention implemented.

Conclusions

- Results and observations show that external awards like gaining pluses for completed activities motivated students to be more engaged and active in lessons.
- Non competitive atmosphere in classroom encouraged majority of students to solve tasks at their own pace and according to their capabilities.
- But it was shown that gamification doesn’t affect students problem-solving skills since no improvement in task-solving was achieved as shown in **Table 1**.

Recommendations

- As this research has shown, gamification elements could be used if we want to make lessons more interactive and students more engaging.
- Students’ motivation can be extrinsically stimulated but it is not a guarantee that students will achieve better results because of that.
- Improving problem-solving skills is a long process that is more influenced by students' predispositions, affinities, attitudes and perseverance.
- Therefore, research on how or what improves problem-solving skills should be conducted over a longer period of time.

Recommendations

- Next, not all students are prone to group work or competition, especially if they have lower academic results.
- So, it is good to combine group and individual work more often during classes (or research) and allow students to perform activities for a reasonably long time in order to reach the goal at their own pace.
- In order to avoid the student's participation in activities only in the case of receiving points or rewards, it would be good to score other activities as well, such as helping a group member solve a task.

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Thank you!