WITH GAMIFICATION TO COLLABORATIVE LEARNING IN CHEMISTRY LESSONS

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Abstract

Gamification with the use of ICT and with the support of the teacher represents an intense, effective, and creative way of learning. By using it in lessons, it is possible to develop collaborative learning, activate student's prior knowledge and contribute to a better understanding and permanence of knowledge. Cooperative learning gives students the opportunity to explore the learning content more deeply during class and evolve critical thinking, while at the same time having a positive effect on the class climate and the building of close mutual relationships. With both didactic approaches it is possible to create new opportunities for learning, e.g., when the students themselves come up with new problems out of the discussed topic.

The aim of the article is to examine how students accept the use of didactic method of gamification in the form of online applications Quizlet live and Socrative space race. In the centre of attention is the impact which gamification and the use of online applications have on students' motivation to learn, and how they simultaneously with collaborative learning contribute to better students' results, understanding, and permanence of knowledge. Hypotheses on positive impact of gamification and collaborative learning on students' motivation for learning, understanding and students' academic achievements were confirmed by the research.

Key words: *gamification, collaborative learning, Quizlet live, Socrative space race*

Introduction

Gamification (gamification) and collaborative learning (cooperative learning) are two of the newer didactic methods that, when using modern information and communications technology (ICT) - online tools and applications, empower students to shift from the passive role of a listener and observer to an active role of a creator and performer in the learning process. Since the introduction of gamification and cooperative learning in chemistry classes is a relative novelty, minor research was carried out to check the meaningfulness and effectiveness of these two methods.

The research question was formulated: How do gamification, supported by the use of online applications, and collaborative learning affect the learning process?

The following hypotheses were formed:

H1: Gamification, supported by the use of online applications, and collaborative learning expand students' motivation for learning.

H2: Collaborative learning and gamification extend the understanding of learning contents.

H3: There are significant differences between the academic achievements of the students who participated in collaborative learning and those who learned with traditional teaching methods (both groups being students of the Secondary School of Economics and Grammar School Maribor, SEŠG).

H4: There are no significant differences in the academic achievements of boys and girls at SEŠG, who participated in cooperative learning.

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Theoretical Background

Chemistry is one of the fundamental natural science subjects taught in secondary schools. Due to its mathematical nature, it requires logical reasoning and generalization skills, which can cause a lot of problems for students when inappropriate teaching methods are chosen. Therefore, academic achievements are worse than expected (Yusuf, 2014). In order to improve teaching practice, researchers and teacher practitioners have developed numerous alternative teaching strategies and learning methods for more active involvement and better motivation of students in the learning process.

Cooperative (collaborative) learning is one of those alternatives. It is based on the inclusion of students in learning activities that take place in small groups and encourages group dynamics, positive mutual interactions and motivation for learning (Lyman & Foyle, 2002), (Kirik & Boz, 2012), (Sumarti, Aris, & Aini, 2018). As members of a group, students achieve their results through mutual cooperation, which provides opportunities for sharing ideas, empathizing with the thinking and feelings of others, developing the ability to discuss and take the initiative. Through cooperative learning, students can come up with more creative solutions of the problems posed. They can process the subject matter more deeply and with greater understanding (Gülüzar & Ömer, 2016) and prove to the teacher that they have mastered the required knowledge.

In collaborative work, even academically weaker students can contribute to the final product of the group and thus experience success. In any case, all students achieve a better understanding of the discussed topic by explaining it to each other. Last but not least, collaborative work encourages students' positive experience of the school, the teacher and classmates, which is an important basis for their further development in the school environment. It is therefore not surprising that researchers recommend the use of collaborative learning for teaching of chemistry concepts to chemistry teachers, as this method improves academic achievement and reduces anxiety in students (Yusuf, 2014).

Despite the growing trend of using cooperative learning as an active learning strategy (Law, 2011), (Tsay-Vogel & Brady, 2010), this approach is rarely used in chemistry classes (Gülüzar & Ömer, 2016).

Making the learning environment interesting for students is a challenge for teachers at all levels of education. One of the newer didactic approaches that contributes to a more active role and involvement of students in the learning process is gamification (Lee & Hammer, 2011). The exact origin of the term gamification (gamifying) is unknown. It is said to have been named around 2004 by the British Doctor of Mathematics and computer game programmer Nick Pelling. There are also several definitions of the term. Gamification includes both the use of digital games for learning (Renaud & Wagoner, 2011) and the transfer of game principles and elements to other activities with the aim of increasing the participation and interest of attendees, i.e., motivating someone to perform a certain activity (Zichermann & Cunningham, 2011). Gamification has found its place in marketing for promotion of products and services, in politics, health, fitness, and also in education.

With computer games or online applications, based on exploration and experimentation, many educational goals can be achieved, such as the ability to solve problems creatively (Gee, 2008), divergent thinking and persistence (McGonigal, 2011), empathy and mutual cooperation, while simultaneously using the motivational power of games - different levels of uncertainty or unknowns in the game, as well as the reward effect (Kapp, 2012).

Gamification evokes many strong emotions in students, from curiosity and frustration to joy and satisfaction. Based on competition, the game provides many positive emotional experiences, such as optimism and pride (McGonigal, 2011). In addition, it allows participants to overcome their negative emotional states and transform them into positive ones (Lee & Hammer, 2011).

Furthermore, it enables the student to experience mistakes and failures, which can be transformed into final success and satisfaction by trying persistently, learning from one's mistakes and using improved approaches (Gee, 2008). In an environment, where effort and not perfection is rewarded, students can internalize the fact that mistakes are an integral part of learning and not a source of fear, helplessness, and uncontrollability.

Gamification makes learning a satisfying experience, as it covers the line between formal and informal learning and thus inspires students for lifelong learning, as well as giving the teacher an excellent tool to guide and reward students in the process of achieving their goals (Lee & Hammer, 2011).

Research Methodology

The aim of a minor research was to find out how the use of the didactical method of gamification in the form of online applications Quizlet live and Socrative space race through collaborative learning affects students' motivation for learning and their achievement of understanding the learning content. As can be seen from Table 1, the research included 57 students aged 16 from two classes of the first-year economic technician programme at SEŠG Maribor, who were taught chemistry by the same teacher.

Table 1
Numerical Composition of Students of the Experimental and Control Group

	Number of students	Number of boys	Number of girls
Experimental group	31	8	23
Control group	26	13	13

The students of both groups had previously tested both online applications several times in class. An experimental group of 31 students learned the subject matter Organic compounds with the help of gamification in the form of cooperative learning, while the control group was represented by 26 students of the second class who studied the same subject with traditional teaching methods and forms - individual solving of the worksheet's tasks and feedback of the teacher. The members of the control and experimental group included in the study were both boys and girls.

A quasi-experimental pre-test-post-test research approach was used for the study. The instruments for data collection were a written test of the discussed chemistry content and two survey questionnaires, which were filled in by the students of both groups before and after the performance in class. Academic achievements of the two groups of students were compared using average grades in the paper test which the students wrote at the end of the content section and after the activities in class.

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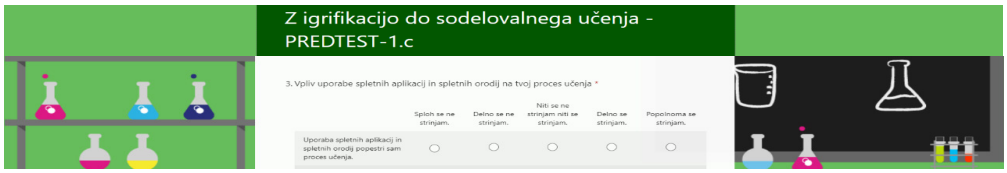
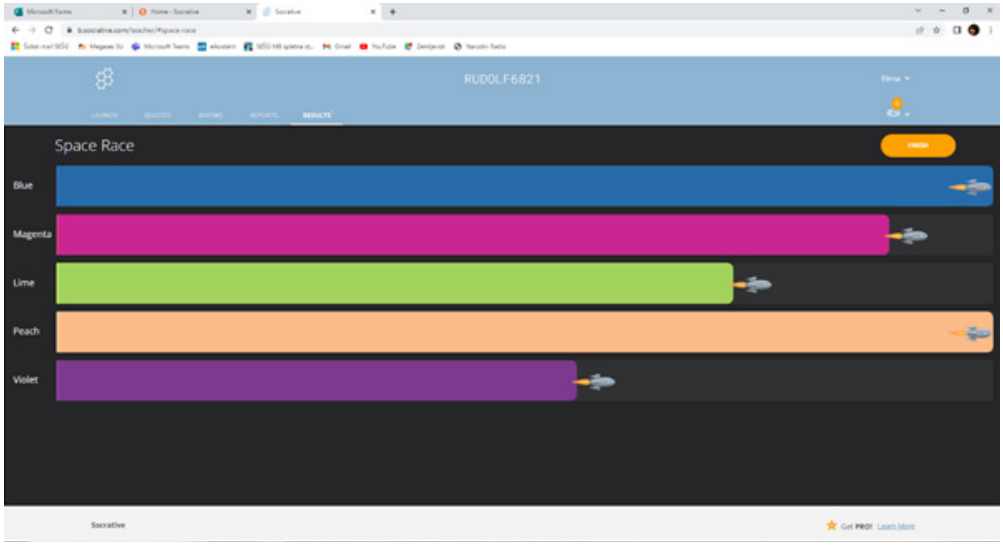
Before reviewing the topic of Organic compounds, the students of the experimental and control groups filled out a survey questionnaire in the form of a pre-test, which was sent to them via the virtual chemistry classroom and created in the online tool Microsoft Forms.

Figure 1
Survey Questionnaire – Pre-test



During the lesson itself, the students of the experimental group solved the tasks given in the online application Socrative space race, by competing with other groups of 6 students and trying to find the correct solutions as quickly as possible through collaborative work.

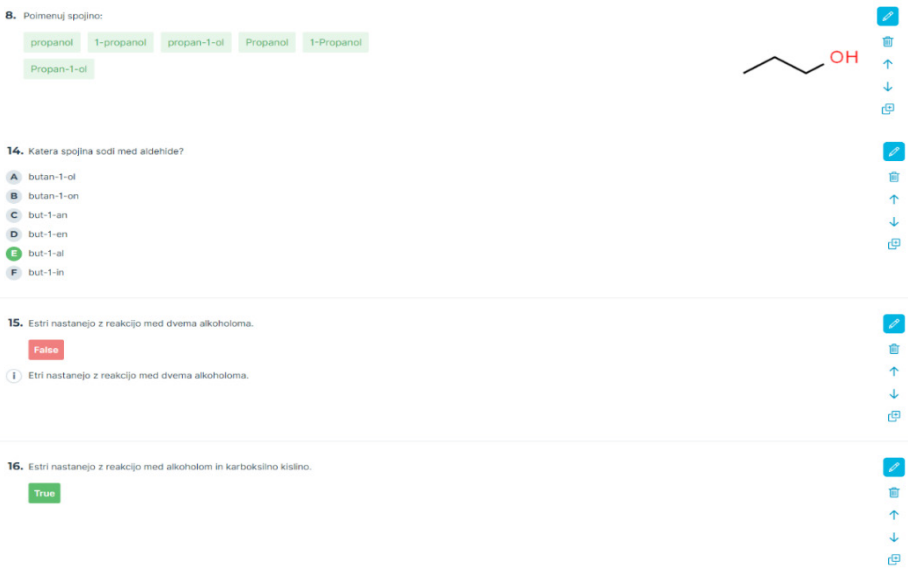
Figure 2
Group Results after Collaborative Work



The online application Socrative space race randomly assigns students to groups and each student participates with one's own smart device. The members of the group try to solve the task with their joint efforts, receiving immediate feedback on their devices about the correctness or irregularities of their responses. In the case of a correct answer, the group moves forward one step towards the finishing line, while an incorrect answer keeps the group in the same place, and the application gives the student the correct answer with an additional short explanation.

Using the application Socrative space race, the teacher can create three types of tasks - a task with a required short answer, a multiple-choice task and an alternative task (true/false).

Figure 3
Different Tasks for Students in Application Socrative Space Race



After completing the activity, the teacher gets a report with students' results in %, students' answers, their correctness, or irregularity, which enables him a detailed analysis and also helps discover deficiencies in students' knowledge.

Figure 4
Teacher's Report with Results and Group Members' Answers

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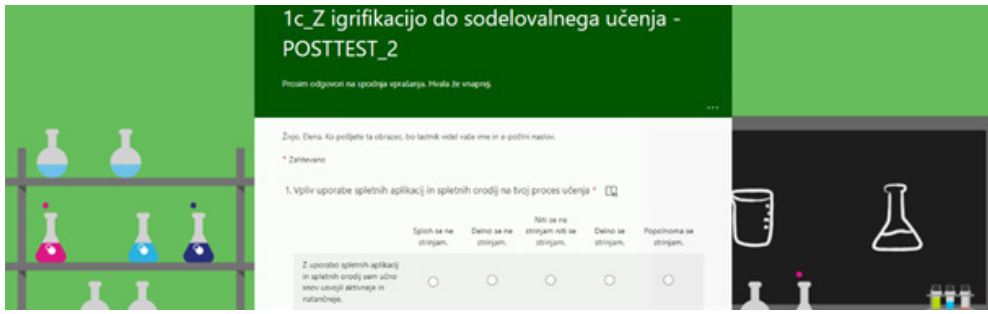
Collaborative work with gamification can also be carried out by the teacher using the online application Quizlet live, which, unlike the application Socrative space race, requires group members to give only one answer to the assigned task, since only one of the answers offered on the smart devices of group members is correct. This way, the group members are forced to cooperate with each other and coordinate their opinions, as they advance on the way to the finishing line only if they give the correct answer, and an incorrect answer returns them to the start. It was observed that a mistake that happens to a particular group just before the finish has a demotivating effect on some students.

After the lesson of revising the subject matter, the students of the experimental and control groups filled out a survey questionnaire in the form of a post-test, which was sent to students again via the virtual chemistry classroom and created in the online tool Microsoft Forms.

Figure 5

Survey Questionnaire – Post-test

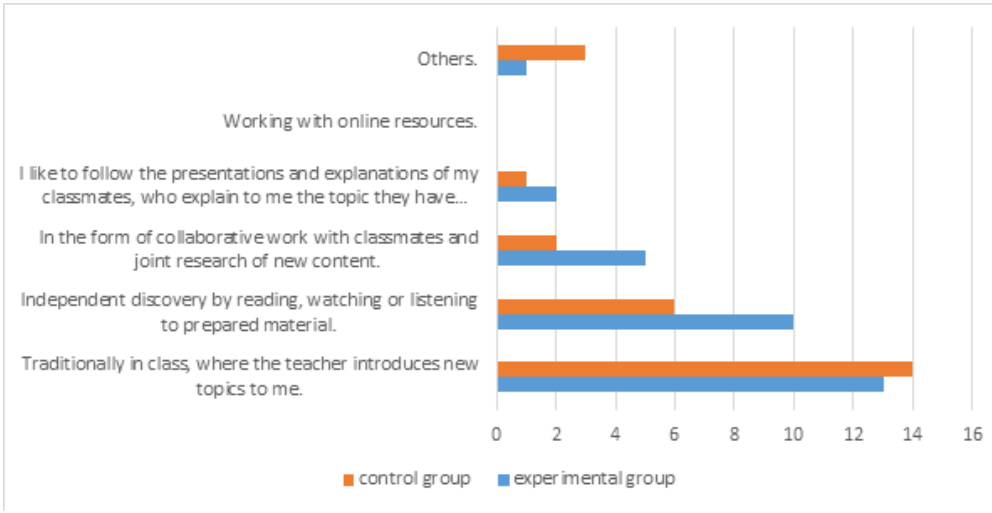


Research Results

Based on the analysis of the survey questionnaires and with comparative analysis of written test results of the students in experimental and in control group, interesting findings were established.

The analysis of answers from the students of the experimental and control group in the pre-test shows a conservative attitude of the students towards the introduction of new methods and forms of learning into the learning process, since the students of both groups prefer to learn traditionally, with new topics presented by the teacher, or they assimilate new material independently by reading, watching or listening to prepared material. These two learning methods are preferred by 23 (74.2%) students of the experimental group and as many as 20 (76.9%) students of the control group, which can be seen in Figure 6.

Figure 6
Forms of learning of experimental and control group of students (pretests)



None of the students from both groups wants to work with online resources, and they are also reserved to working collaboratively with classmates and researching new content together. This is confirmed by 5 students (16.1%) of the experimental group and 2 students (7.7%) of the control group, whereby it is interesting to note that cooperative learning is desired by academically weaker students and students with special needs.

Considering that 47 (82.5%) students of the experimental and control groups point out that they like to cooperate with their classmates in the group, it can be concluded that the students do not understand group work as a way of learning. Figure 7 also shows that about 50 (88%) students of both groups want to share their knowledge on a certain topic with others, and 54 (95%) students of both groups are ready to help their classmates with an additional explanation.

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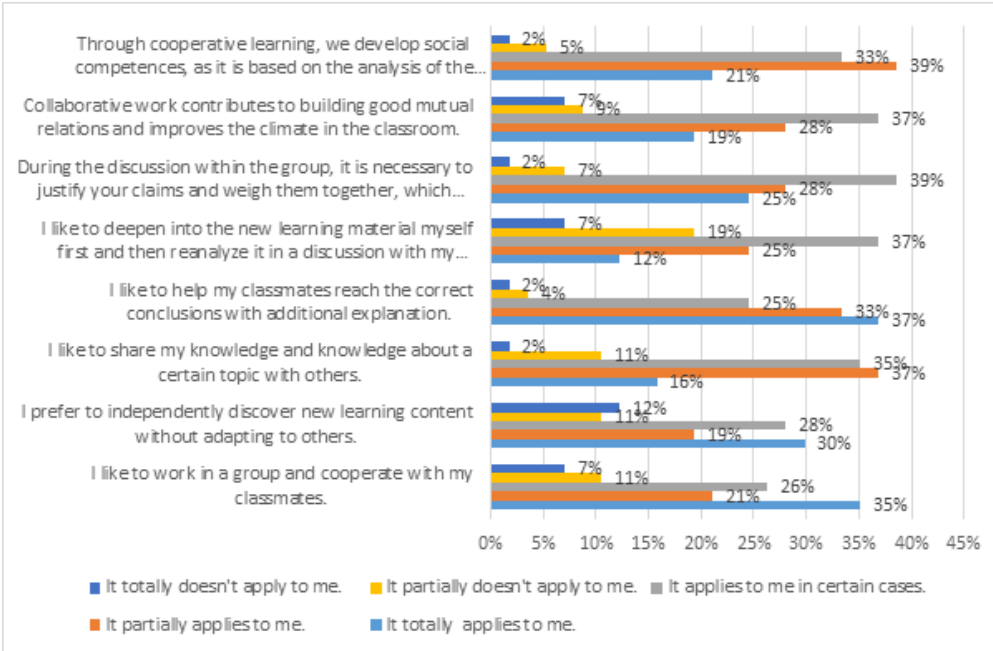
Figure 7

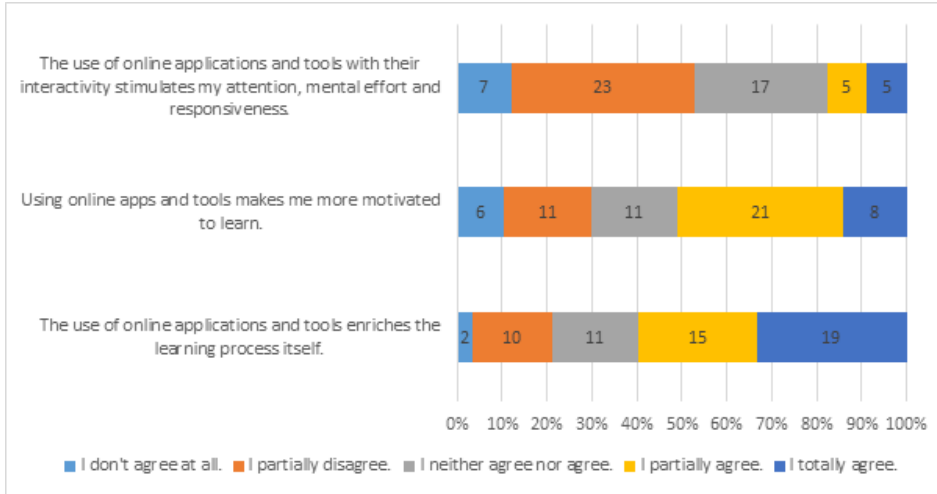
Attitude of Experimental and Control Group Students towards Collaborative Learning (Pre-tests)



The answers of the students of both groups before the intervention show that around 60% of the students are convinced that the use of online applications and online tools has a positive impact on their learning process, as 34 students (about 60%) think that it enriches the lessons, while 29 (50.9 %) of the students believe that it additionally motivates them to study, which is shown in Figure 8.

Figure 8

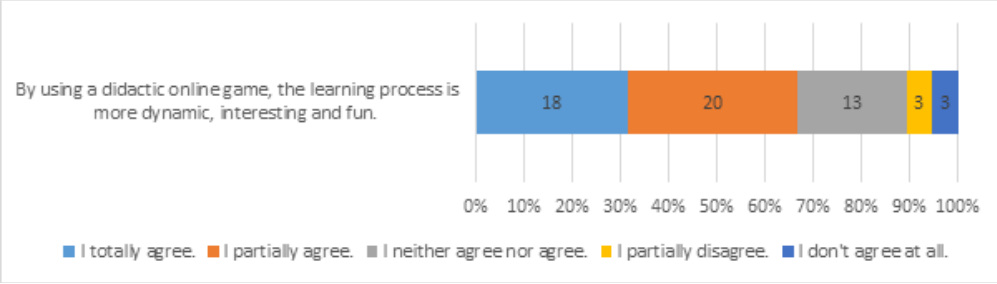
The Impact of the Use of Online Applications and Tools on Student's Learning (Pre-tests)



Distrust in the positive influence of gamification, supported by the use of online applications and tools, on the learning process, which makes lessons more dynamic, interesting and fun, can be seen among 6 students (10.5%) of both groups in Figure 9, while on the contrary, 38 students (66.7%) of both groups are in favour of gamification.

Figure 9

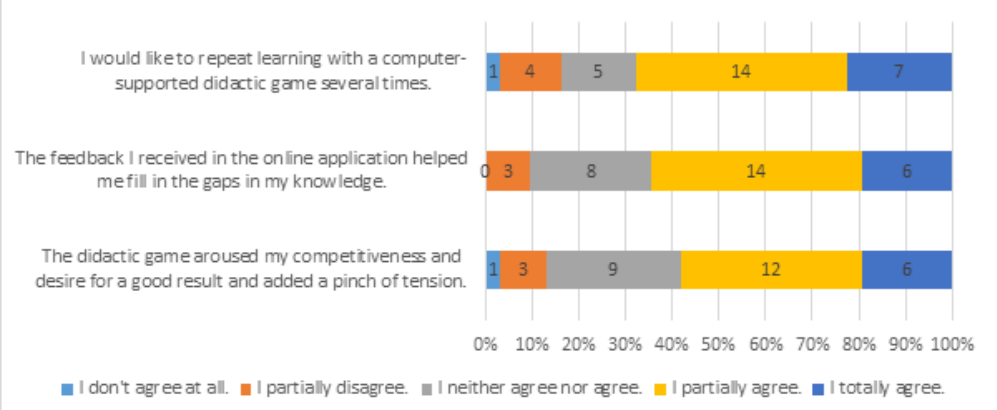
The Impact of Gamification Supported by the Use of Online Applications and Tools on Student's Learning (Pre-tests)



The mistrust of many students towards the use of gamification, supported by the use of online applications and tools and collaborative learning in lessons, turned out to be unfounded after analysing the students' answers in the post-test. Figure 10 shows that with 18 students (a good 58%) of the experimental group, the didactic game aroused competitiveness, the desire for a good result, added a pinch of tension as well as demanded their critical thinking. According to 20 students (64.5%) of the experimental group, the feedback they received in online application helped them fill gaps in their knowledge, and 21 students (67.7%) of the experimental group would like to repeat learning with a computer-supported didactic game several times.

Figure 10

The Impact of Gamification Supported by the Use of Online Applications and Tools on Student's Learning (Post-test)



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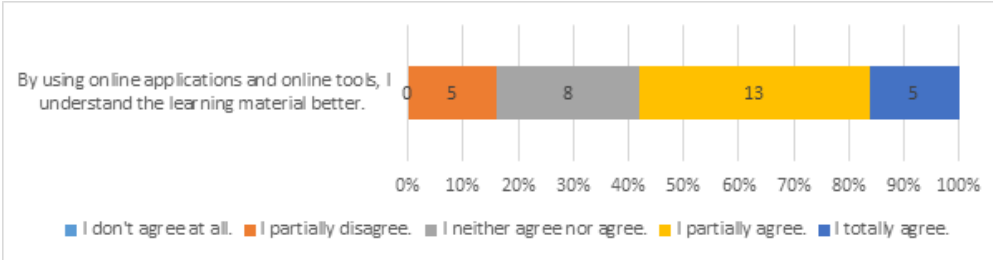
The effects of gamification, supported by the use of online applications and tools, on the learning process can also be clearly seen in Figure 11, as 18 students (58.1%) of the experimental group believe that the use of online applications and tools contributes to better understanding of the learning material.

Figure 11

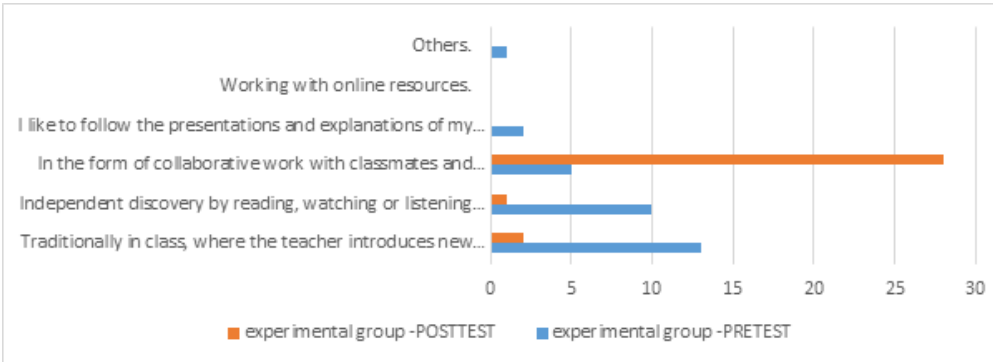
The Impact of the Use of Online Applications and Tools on the Student's Learning (Post-test)



A comparison of answers of the experimental group students in the pre-test and post-test clearly shows that after the activity in the class, the balance has strongly tilted in favour of cooperative learning, compared to other forms of learning. From the initial 5 students (16.1%) of the experimental group, now 28 students (90.3%) are in favour of cooperative learning, which can be seen in Figure 12.

Figure 12

Forms of Learning of Students in the Experimental Group (Comparison of Pre-test and Post-test)



As can be seen in Figure 13, out of the initial 8 students (25.8%) after the intervention, 25 students (80.6%) of the experimental group believe that collaborative learning contributes to a better understanding of the discussed learning content.

Figure 13
The Influence of Cooperative Learning on the Understanding of Learning Content (Comparison of Pre-test and Post-test)

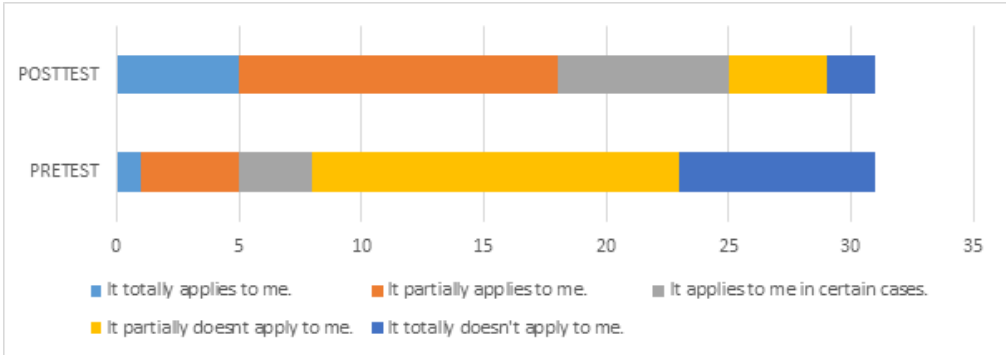
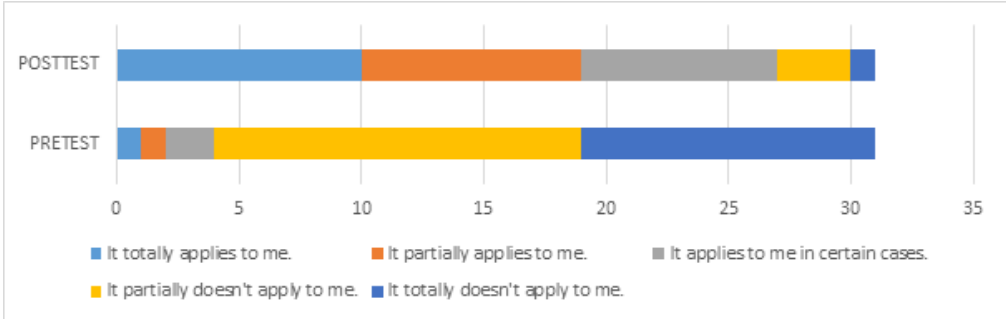


Figure 14 shows that after the intervention, the initial number of 4 students (12.9%) of the experimental group, who believe that collaborative work increases the motivation for learning and further research of the subject, increased to 27 students (87.1%).

Figure 14
The Influence of Collaborative Learning on Learning Motivation (Comparison of Pre-test and Post-test)



The findings of minor research point out the significant difference in understanding of discussed chemistry concepts and students' motivation for learning in favour of the experimental group.

Discussion

Participating students of the experimental group believe that gamification, supported by the use of online applications and collaborative learning, has a distinctly positive impact on students' motivation for learning, as it enriches the lesson and stimulates their attention, mental effort and responsiveness with its interactivity. This confirms hypothesis H1, which was checked with the first paragraph of question 3 and with the fifth paragraph of question 2 in the post-test, and also stated by (Lyman & Foyle, 2002), (Sumarti, Aris, & Aini, 2018). According to the students, revising the learning material with the help of online applications

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and tools is more dynamic and effective than filling in individual worksheets, because this way the students assimilate the learning material more actively and accurately. According to the implementing teacher, this form of teaching is more suitable for introducing new learning content and revising learning material than traditional lessons led by a teacher.

The students estimate that the computer-supported didactic game motivated them to actively cooperate with their classmates in the group through collaborative work, which, according to the students, contributed to the activation of their prior knowledge and a better understanding of the discussed learning content, as each individual member of the group received more feedback - both by the other members of the group as well as immediate feedback in the online application. This confirms hypothesis H2, which was tested with the sixth paragraph of question 4 in the pre-test and with the second paragraph of question 1 and the first paragraph of question 2 in the post-test, which is also highlighted by (Gülüzar & Ömer, 2016). According to the students, collaborative work contributes to a more comprehensive, in-depth and permanent knowledge, as well as greater motivation for learning and further research of the discussed topic.

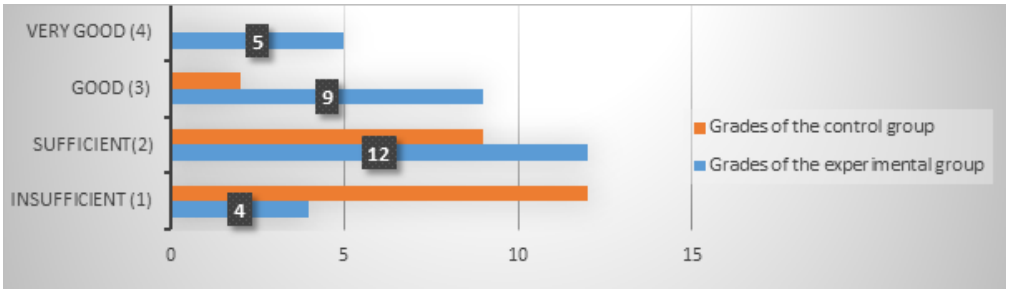
The implementing teacher noticed that by using online application in the form of collaborative work, the students achieved a higher level of understanding of the discussed topic, as they were better prepared to use the acquired knowledge in new situations - new tasks after the implementation in class. They were also more actively involved in discussions and came to faster and better solutions to the problems posed, which is also written about (Gülüzar & Ömer, 2016).

During the cooperative learning lesson, the teacher can observe and analyse the learning process better and more accurately, as he is in the role of an advisor and consultant. This enables him to adapt to the various individual needs of the students and, with additional instructions, ensure more active participation even from academically weaker students and students with special needs, which is also indicated by (Lee & Hammer, 2011). The latter in particular are not left to their own devices due to the collaborative work, but can clarify all obscurities and also assimilate more demanding chemistry concepts with the help of their classmates and the teacher. With collaborative work, students learn from each other and not only learn the correct solutions and solving procedures, but also learn how to explain to a classmate why these solutions are correct.

The analysis of the results of the written assessment, which was used to check and evaluate the knowledge of Organic compounds by students of the experimental and control group, showed a significant difference between the achievements of academically weaker students in both classes, which is shown in Figure15. In the experimental group, only 4 students were evaluated negatively, while 12 students of the control group, who were taught traditionally, were evaluated negatively. All 3 students with special needs in the experimental group were evaluated positively. This confirms the distinctly positive impact of gamification and cooperative learning on the motivation and understanding of chemistry concepts among academically weaker students.

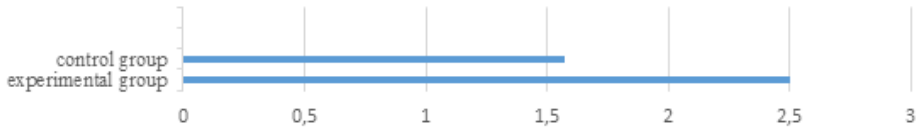
Among those positively evaluated in the experimental group, there were 12 sufficient, 9 good and 5 very good grades, while in the control group only 9 sufficient and 2 good grades.

Figure 15
Grades Achieved by Both Sections in the Written Test of Organic Compounds



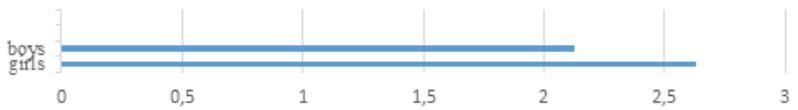
The average grade of all students who were assessed in written test was higher among students of the experimental group, who were involved in cooperative learning (totaled at 2.50 out of 5), than among students of the control group, who learned with traditional teaching methods (came to only 1.57), which confirms hypothesis H3 and can be seen in Figure 16, and also states (Yusuf, 2014).

Figure 16
The Average Grade of Both Sections in the Written Test of Organic Compounds



Hypothesis H4, i.e., there are no significant differences in the academic achievements of boys and girls who received cooperative learning, proved to be correct, as the average grade of the girls in the experimental group was 2.63, while the boys scored a slightly lower average of 2,13, which can be seen from Figure 17.

Figure 17
The Average Grade of Girls and Boys of the Experimental Group in the Written Test of Organic Compounds



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The findings of the performed research point to a significant difference in the understanding of the discussed chemistry concepts and the students' motivation for learning in favour of the experimental group, which is also confirmed by their better academic achievements.

Conclusions

With the help of collaborative work encouraged by gamification, students were able to acquire new knowledge, consolidate skills and develop their social competences. This way, the students took on an active role in the learning process, while the teacher was merely an advisor and moderator throughout the learning process. The time, otherwise intended for classic consolidation and revision of the learning material, was now dedicated to mutual cooperation, finding answers to the questions asked, analysing the different opinions of individual members of the group and formulating as well as arguing a common solution to the problem. Through collaborative work, students received an opportunity to build closer mutual contacts (Lyman & Foyle, 2002), (Kirik & Boz, 2012), (Sumarti, Aris, & Aini, 2018), share ideas and empathize with the thoughts and feelings of others, which has a positive effect on the overall climate in the classroom.

Collaborative learning has a significant impact on the motivation and understanding of chemistry concepts by academically weaker students (Lee & Hammer, 2011), as the teacher can provide them with a more individual learning support. The time spent in the classroom is thus used more efficiently and is more goal-oriented, as the teacher can create more opportunities for the integration and application of knowledge and the active use of higher-order cognitive functions. The dual feedback provided during computer-assisted collaborative learning helps students clarify the content and potential misconceptions, ensuring that students organize new knowledge in a way that is more appropriate for future use. Feedback helps students fill the gaps in their knowledge, enables them to upgrade their knowledge and motivates them for further deepening and exploration.

The added value of collaborative learning supported by gamification is in the dynamics and diversification of lessons, greater motivation for learning, increased understanding of learning content and achieving the permanence of knowledge, as well as developing social competences and maximizing good interpersonal relationships and a sense of belonging. Based on this year's positive experience with the use of gamification and cooperative learning in discussion of Organic compounds subject matter in first class of secondary school, the plan is to expand the use of these two didactic approaches in the following school year with various learning contents in curriculum of secondary school educational programme and to test its use in circumstances of distance education.

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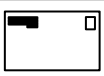

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