

# Gamification for developing computational thinking in blended-learning environment: students' motivation and assessment problems

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**Abstract.** This contribution addresses the problem of making computer science learning and computational thinking development more attractive for high-school students. For this purpose, “Minecraft: Education Edition” environment was chosen as “Minecraft” is one of the most popular games among pupils. Series of remote and in-class computer science lessons were conducted with a class of 9th grade students in the “Minecraft: Education Edition” environment. For the remote learning “Discord” platform was used, which further improved student motivation. Unplugged computer science activities were used to support learning for more challenging programming concepts. In order to explore students' motivation and computational thinking development process we use observation and qualitative survey research methods. The survey has shown that students' attitudes towards the “Minecraft: Education Edition” platform are very positive. Students pointed that learning in this environment, which is already familiar for them, gives much more fun and tasks are easier to understand and easier to perform by seeing their visual representation. The tasks in “Minecraft: Education Edition” environment allowed the students to discover and use certain CT concepts themselves, such as decomposition. Unplugged activities helped students to understand fundamental concepts. However, computational thinking assessment issues in gamification environments appeared as a field that needs more research.

**Keywords:** computational thinking, gamification, Minecraft: Education Edition, blended-learning, motivation, programming, computational thinking assessment.

## 1 Introduction

Students today spend most of their free time using social networks or playing computer games. The amount of time devoted to these sessions has increased significantly during the quarantine period. It would be useful to direct students' daily activities in the direction of learning.

Recent studies on Game-Based Learning (GBL) state that such learning motivates students and provides opportunities to explore and acquire more knowledge and skills [2]. Game-based learning is based on the integration of knowledge and new skills into the content of the game in its environment, and the game activity itself involves students

as players in solving problems and giving them a sense of victory [2]. By using an inclusive game environment, it is possible to convey the desired information to students and develop their relevant skills. In this work, we analyze the knowledge and skills required for the subject of computer science that games can provide.

Minecraft (has over 140 million users worldwide [4]) is one of the most popular games currently played by students. The Minecraft game platform has a well-developed training version - Minecraft: Education Edition [1]. In this platform it is possible to learn not only computer science (programming), but also teaching materials for other subjects (English, History, Geography, Science, etc.) are provided.

One of the goals of computer science teaching is to develop computational thinking. Computational thinking is defined as a particular ability to think that could be transferred from computer science and adapted to solve complex real-world problems [3]. Minecraft: Education Edition has content to offer for computational thinking development.

The aim of this pilot study is to find out how learning computer science in the Minecraft: Education Edition environment remotely and in-class increases students' motivation to learn and facilitates the understanding of programming concepts. The additional objective is to preliminarily observe possibilities how students acquired computational thinking skills could be assessed.

## **2 Study design**

### **2.1 Respondents and research structure**

In the pilot study participated one class (24 pupils) of 9th grade students. The study was conducted remotely and in-class. It consisted of two parts: observation of students' behavior during the lessons, and a questionnaire which was given to students after a six-lesson cycle. 15 student responses were received, including 8 girls and 7 boys (gender distribution was even).

As circumstances changed and opportunities arose for students to study in-class, the research was extended. In order to better understand the basics of programming, the Minecraft: Education Edition activities were augmented with “unplugged” tasks. At this stage we used observation method and a knowledge test taken by the students in the Kahoot environment.

Before the observation we posed several questions. How students feel and what emotions they demonstrate during learning process? Does working in groups has any impact to the students' learning? What strategy students use for solving difficult tasks? Do “unplugged” activities help to understand more complex programming problems?

### **2.2 Preparation for the research**

In preparation for the study, the main challenge was the lack of knowledge about the subject matter of the Minecraft game itself. We would like to point out this aspect, understanding the idea of the game is even more important than a technical mastery.

As Šajben et al. [5] mention using the Minecraft: Education Edition environment makes students feel stronger in it than teachers.

In remote learning, there was a need for several students to be able to share their screens at the same time, and for teacher to be able to see how they were doing in the tasks, what issues and challenges they were facing. For this purpose, the Discord communication platform used by computer game players was chosen. This platform was well known to almost all students.

### 2.3 Student observation results

Throughout the lessons, students' behavior during the tasks was observed by the teacher. No homework was given during this period, but several students who failed to complete all the tasks during the lesson admitted that they completed them on their own when they returned home, indicating that the environment is attractive and inclusive for the students.

If the task performed corresponded to the level of perception of the students, they became so involved that they remained connected even during the break. If the task was difficult, some would not try to write the whole code at once but write it in parts and test how it works. The students themselves discovered the decomposition to complete the tasks. As students were regrouped with each lesson, this practice of decomposition has spread.

Observations revealed that student work in groups was very useful when more advanced students could help others. The game environment relaxes them, and students communicate more freely in solving tasks.

Students struggled with understanding the “while” loop. After this thematic lesson, students had the opportunity to return to school live. In the first lesson, unplugged tasks were given. Students completed these tasks in groups. After this lesson, students solved the tasks in the Minecraft: Education Edition environment much better. The inclusion of unplugged activities is helpful in improving students' understanding of learning programming. However, more research is needed in this area.

### 2.4 Survey results

The majority of students (74%) answered positively to the question: “How does learning in the Minecraft: Education Edition game environment affect your motivation to learn computer science?”. Learning in this environment also helped students (73% of them mentioned) to better understand the purpose of the programming itself. In the open questions part students wrote more specifically what they like about this environment: “environment, view, I like that I can build there, and not just tasks, because when we studied with Scratch, there were only tasks given by the teacher, which were difficult to understand”; “the game itself and its principle is very cool, all Minecraft education I couldn't single out one thing”; “I liked that the Minecraft has 3 dimensions”; “that it feels almost like a game and then it's more fun to do tasks”; “that you can see the result of your code in your favorite game”.

### 3 Conclusions

The results of the study confirmed that computer science learning in the Minecraft: Education Edition platform is attractive for students. They appreciate the environment itself, noting that learning to program in this environment makes programming more understandable and appealing.

However, there was an assessment problem in teaching in this environment. The tasks themselves are done in such a way that if they are not done correctly, it is not possible to move on to another task. So, students have to repeat the task many times until they complete it correctly. But this does not at all show their level of perception and thinking. After all the lessons, the students were given a test in the Kahoot environment. The result of the whole class of correct answers of the test was 51%. Clearly, Kahoot has a time-limit aspect that could have had a big impact on the results.

It is also very important to see how students think while they do one or another activity, how and why they choose one or another solution. More research is needed in the area of computational thinking assessment. As Zhang et al. [6] and other research mention, some computational thinking skills, still remain a challenge in how to properly assess them. An attempt should be made to assess how students assimilate concepts of computational thinking. The test included algorithmic concepts, and students discovered and shared the concept of decomposition while performing tasks. The research will be continued precisely in the context of assessment of computational thinking: what principles are the most suitable for assessment and show the best how students are able to master these concepts.

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