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Minecraft in STEAM education - applying game-based learning to renewable energy

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Abstract. One of the essential tasks of teaching STEAM subjects (Science, Technology, Engineering, Arts, Mathematics) is to motivate and engage students. This can be achieved through new interactive, experiential teaching methods, such as game-based learning. Minecraft is a multiplatform video game already popular among students and can be successfully used in game-based education. The study presents the application possibilities of Minecraft in integrated education of STEAM fields through the example of teaching a specific topic. The development was tested within the framework of a summer camp, where the 10-16-year-old participants explored the topics of renewable energy sources with Minecraft. Based on the experiences and researchers of the camp, the application of game-based learning with Minecraft was successful in raising students' interest, increasing their motivation, mastering the knowledge material, productive task solving and cooperation to work on sustainable development goals.

Keywords: game-based learning, Minecraft, methodological innovation

1 Introduction

Teaching STEAM fields worldwide is characterised by methodological renewal, as the need for learning and teaching to become an experience is increasingly becoming important - especially in science fields that are otherwise non-favoured with students and difficult for them to learn.

Breuer & Bente [1] highlight a common issue with educational games, noting that their design often prioritizes learning objectives over entertainment value. This focus can impede both student engagement and learning outcomes if the gameplay lacks sufficient challenge. The appearance of the idea of experiential pedagogy can be linked to the pedagogical work of John Dewey, according to whose views the student's own experience should be at the centre of the teaching-learning process [2]. The methods based on experience-based learning (ExBL) [3],[4] build on the students' direct experiences. By processing the subjective experience, they make experiences and learning itself more sustained so that students can experience the so-called flow experience, i.e. the state when learning is not felt as an obligation, it is considered attractive, it is a challenge for them, and difficulties do not deter them, but inspire them to find solutions.

Experiential learning starts from the experience itself. It is through experiencing, processing and reflecting on it that actions become cognition. It is an active learning process that builds on learners' curiosity, is well suited to the characteristics of human cognition, adapts to changing environmental conditions, and challenges learners to new and new challenges [5]. Learning can become an enjoyable adventure if solving tasks fills students with joy and pride. Flow is "the phenomenon when we become so absorbed in an activity that everything else dwarfs it; the experience itself becomes so enjoyable that we want to continue the activity at any cost, just for its own sake" [6].

The game-based learning (GBL) enables experience-based learning using games and game elements [7],[8]. Game-based learning is a process of learning through play, aiming at the transfer of knowledge and skills [9]. Game-based learning can make education more exciting and effective [10], raise students' curiosity and motivate them [11]. Research results prove that besides the above, game-based learning improves students' logical and algorithmic thinking, problem-solving skills and creativity [12-16]. According to Prensky [17], in game-based learning, the content and process of the game improve knowledge transfer and skill development. Game activities provide challenges that give learners a sense of achievement. Renninger and Bachrach [18] investigated the motivations of high school students and determined the influences that maintained their attention and motivated them. Autonomy, challenge, computers/technology, group work, individual activity, instructional conversation, novelty, and personal relevance were highly motivating.

Digital game-based learning (DGBL) describes learning using a game-based learning application on a digital device [17],[19].

Prensky [17] summarised the characteristics of digital game-based learning in 12 points: "1. Games are a form of fun. That gives us enjoyment and pleasure. 2. Games are a form of play. That gives us intense and passionate involvement. 3. Games have rules. That gives us structure. 4. Games have goals. That gives us motivation. 5. Games are interactive. That gives us doing. 6. Games are adaptive. That gives us flow. 7. Games have outcomes and feedback. That gives us learning. 8. Games have won states. That gives us ego gratification. 9. Games have conflict/competition/challenge/opposition. That gives us adrenaline. 10. Games have problem solving. That sparks the users creativity. 11. Games have interaction. That gives us social groups. 12. Games have representation and story. That gives us emotion." James Paul Gee contends that games embody various learning principles that render them more effective as learning tools compared to conventional classroom settings [20] Gee defines a game in two components: the game itself and "the entire social system of interactions in which players partake both within (in the case of multiplayer games) and outside the game, often referred to as the meta-game" [21].

Digital games create an active and engaging environment for learning, problem-solving and collaboration. They create a safe, virtual space where learners can play, explore, experiment and have fun [18].

A well-studied concept in the context of game-based learning (GBL) is intrinsic motivation, drawing heavily on the foundational ideas presented by Mark Lepper and Thomas Malone in 1987. Intrinsic motivation is characterized by engaging in activities purely for the inherent satisfaction they bring, such as playing a game simply for the enjoyment of the game itself or learning out of a desire for knowledge and personal growth, akin to someone reading a book for pleasure and self-improvement, without any anticipation of external rewards or recognition [22].

The metaverse, as a new generation of virtual universes, brings the physical and digital world closer together, in which education, knowledge transfer and skill development raise new dimensions and questions simultaneously. The Minecraft Education platform interprets the aspects of the already existing physical world into the digital environment, which brings with it the digital identity of the participants (avatar), their possibilities of action within the system (transhuman abilities), the creativity to achieve the set educational goals, the cooperation opportunities, the transition from text comprehension to multimodal literacy and, last but not least, the game generated a sense of community. [23]

The Minecraft ecosystem now provides a unique and forward-thinking digital experience for children strongly linked to distinctive digital literacy practices [23]. The Minecraft game can be considered discursive because the metalanguage it uses, its rules of design and combination, and its unique world and logic create a new system of meaning. [24]

Yi et al. [25] investigated the maintenance and development of long-term interest in the STEM field through the example of the application of the Minecraft game. They found that personal relevance played a prominent role in the use of Minecraft. Hughes [26] successfully used the Minecraft program to develop spatial skills in a summer camp for high school students.

Today, children's online games increasingly connect digital and non-digital areas, and posthumanist theories help create these time planes and meta-spaces. [27]

2 Related work

Computer and video games - including Minecraft - are becoming increasingly widespread and popular among children, young people, and adults. Minecraft boasts over 166 million monthly active players. Since its release in 2011, 600 million copies of Minecraft have been sold. The Chinese edition of Minecraft has seen over 400 million downloads. Covid-19 significantly impacted Minecraft, with the number of active players increasing by over 14 million from 2020 to 2021 according to searchlogistic.com. [28] In the first quarter of 2021, Based on Gitnux data Minecraft was the most-downloaded game on Google Play, achieving 16.8 million installs [29].

In sandbox games, there is no linearity and no mandatory stages. Sandbox games lack linearity and obligatory stages, providing players with the freedom to explore and create as they wish. Similar to real-world playground sandboxes, players can construct sandcastles anywhere, guided by their imagination. These games offer an open-world experience where creativity knows no bounds.

Using an artistic analogy, sandbox games resemble a painter's studio equipped with a blank canvas, paints, and brushes. Players are the artists in this digital realm, and the game serves as their canvas. The vast, open environment and the tools at their disposal allow players to craft their unique experiences. It's the artist's imagination and toolkit that determine what fills the available canvas, and the possibilities are limited only by the player's creativity.

Sandbox games exemplify the fusion of technology and art, enabling individuals to express themselves, tell stories, and embark on adventures that are entirely their own. As virtual worlds continue to expand and evolve, so does the potential for imaginative exploration and boundless creativity in sandbox gaming.

Educational developers have noticed this game and, emphasising the peculiarities of the teaching-learning process, have developed Minecraft Education Edition, a version of Minecraft for education [24],[25],[26],[27],[30], which has a rich technological background and toolbox [31].

In Minecraft, learning takes place in a simulated world. The goal is not to win but to experience the game. The characteristic of Minecraft is that it maps reality, and participants can create new worlds, thereby experiencing the joy of creation. The virtual world of the game consists of 3D elements called blocks (cubes). These can be made up of natural and artificial materials and create the possibility of building different objects (e.g. buildings) and dismantling the elements. The player sees this virtual world from his point of view and can look around up to 360°. Participants can play individually and in groups, with multiple players joining the world at the same time), creating collaboration opportunities [31].

Minecraft has three different game modes: creative, survival and hardcore.
The creative mode is not a classic one but uses a toolbox with a choice of objects, including almost every block and tool.

In survival mode, players must harness resources to build while fighting different creatures.

The hardcore is a more complicated version of the survival mode. It means that once players are dead, they do not return to their starting position, so the game ends for them. Minecraft is, therefore, well suited to different areas of education, especially STEAM areas [32]. It can bring the world of science closer to students, and the simulated environment offers excellent opportunities for creative design and modelling of phenomena.

The applicability of Minecraft in STEAM fields is explained in a study by Short [33]. For example, in biology, Minecraft allows students to learn about the world modelled on the human body, organs, and biological degradation processes. Within ecology, it can play a role in introducing biomes, especially if there is no other way to introduce and illustrate forest species and woodland in the classroom. The teacher can even use Minecraft to organise a virtual field trip to a desert, a jungle or even the Arctic. Students can be shown what happens when trees are cut down in a large area, and the process of desert formation can be demonstrated. In chemistry lessons, Minecraft can contribute to learning about the explosion process of TNT, for example, and building molecular models from blocks [34]. Students can improve their maths skills by calculating areas and perimeters when building their imaginary world (e.g. calculating how many fences are needed to enclose their flower garden) and learning about the properties of different shapes. The game not only helps them to develop their problem-solving and logical skills but also their spatial vision and orientation. In Minecraft's varied play environment, students learn about the world through exploration and experimentation.

When it comes to non-violent, educational games, Minecraft arguably leads the way. It can teach kids the basics of programming skills, teamwork, problem-solving and project management and provides a great environment to foster creativity and out-of-the-box thinking [35],[36].

With the help of Minecraft Education or other essential Minecraft software, educational goals can be strengthened, and intelligence factors can be more easily activated through the following areas:

1. Stimulation of creativity and project planning: Minecraft is an open-world game that allows players to create anything they can imagine using virtual blocks. This type of gameplay is ideal for stimulating creativity and project planning, as players have unlimited resources to design their worlds, buildings, and objects. Players can experiment with different materials, shapes, and colours to create unique structures and landscapes, helping to foster creativity and imagination.
2. Programming and logic skills: Minecraft allows players to learn programming and logic skills. Players can use Minecraft's command blocks to create complex structures and automate tasks, which requires an understanding of basic programming concepts. The program can help players develop critical thinking and problem-solving skills essential for future careers in technology and engineering.
3. Teamwork communication: Teamwork and communication are essential for success in any collaborative project. Minecraft provides a platform for players to work together to achieve common goals, whether building a community or completing a quest. Players can communicate through chat and voice chat to coordinate their efforts and share ideas, helping to improve their teamwork and communication skills.
4. Increasing problem-solving ability: Minecraft is a game that requires players to solve problems constantly, whether it is navigating through a maze, defending against enemy attacks, or finding resources to survive. Players must think creatively and critically to overcome these challenges, improving their problem-solving skills.
5. Strengthening social skills in autistic children: Minecraft can be a helpful tool for improving social skills in autistic children. The game provides a safe and structured environment where children can interact with others and develop social skills. It allows them to work together with others, build friendships, and practice communication skills, which can be particularly challenging for children on the autism spectrum.
6. Resource management: Minecraft also provides an opportunity for players to learn resource management skills. In the game, players must gather resources such as wood, stone, and food to survive and thrive. Players must learn to manage their resources effectively, balancing their needs for survival with their goals for building and creating.
7. Perseverance dedication: Minecraft can help develop perseverance and dedication. The game is designed to be challenging, requiring players to work hard to achieve their goals. Players must be patient and persistent,

learning from their mistakes and continuing to try until they succeed. It also can help develop resilience and a growth mindset, essential for success in life.

3 Method

Test results and recent experiences with Minecraft Education Edition demonstrate its effectiveness as an innovative educational tool in the public education sector. Nonetheless, this iteration of Minecraft provides a world, a collaborative environment, characterized by significant limitations and teacher control. Within this so-called 'minimal world,' the sense of wonder and discovery is somewhat diminished, as students are unable to utilize certain features and accessories available in the standard version, thus missing out on opportunities for creativity and the acquisition of valuable skills. By leveraging Minecraft as an educational tool, the envisioned educational framework introduces gamified educational methodologies that are inherently engaging, interactive, and conducive to a wide range of learning objectives. This innovative approach not only captures the imagination and interest of students but also supports the development of critical 21st-century skills, including creativity, collaboration, problem-solving, and digital literacy. As such, Minecraft offers a powerful platform for transforming traditional educational practices and paving the way for future innovations in gamified learning

The evaluation of global problems, along with the conceptualization and implementation of the UN's Sustainable Development Goals in Education, reveals the need for an entirely new, innovative green development education plan within the pedagogical society. This plan should be formulated on the principles of environmental protection and combating climate change. It is essential to develop critical competencies while adopting a STEM/STEAM-focused approach to enhance students' interest in natural sciences.

Minecraft, modified with energy supplements proves to be an innovative learning environment that has excellent potential for use in education for sustainable development goals through multidisciplinary STEAM approaches. The game's potential for learning is due to its virtual reality and game-based learning environment, which can be used to put the future at the centre of learning [37]. Studies have shown that commercial video games, like Horizon Forbidden West, can be used to create environmentally sustainable game worlds [38]. Metaverse, the virtual universe concept, can be utilised in classrooms to create new learning environments [39]. BetterGeo is a Minecraft modification designed by the Geological Survey of Sweden to help primary school students understand geology, minerals, mining, mineral processing, and circular economy. The initiative has created a series of learning materials and interactive games to help teachers and students learn about raw materials. Serious gaming has also been used to communicate climate change and its effects. The game design incorporates Education for Sustainable Development's key goals, combining comprehensive views, action competence, learner engagement, and pluralism [40].

Illustration, modelling and realistic simulation provide space for detecting dangerous situations. The virtual space creates the entire field table for it, where can not cause further natural damage by testing. Actions can be corrected, but in the case of a game mode change, similar properties to those of a natural person may emerge; thus, the gravity of actions can be felt, and unlimited power is not held within the created playing field.Game-based learning can be an effective training methodology because it increases the attractiveness of learning processes, innovation, fun, productivity, and the ability to retain knowledge and acquire new skills.

If Minecraft develops all of these, it might be advantageous to also introduce scientific fields that do not fit into the framework curriculum. The studied subjects could be used to arouse interest in these areas among elementary school students.

Embedding informal STEAM modules into secondary school students' study programmes was shown to trigger both creativity level and career choice preferences [41]. Their career orientation can already be influenced here as planned.

Looking to the future of education, it is clear that the intertwining of innovative technologies and the Sustainable Development Goals (SDGs) will play an increasingly important role in shaping students' learning and their engagement with the world. The society are on the cusp of a transformative era in education, and by embracing dynamic approaches such as game-based learning, there is an opportunity to inspire the next generation of thinkers, innovators, and problem solvers who can tackle the complex challenges facing the world.

The researchers explored the educational applications of Minecraft within the framework of a unique Children's University Camp, attended by students aged 10 to 16. The primary objective of the camp was to introduce students to the field of renewable energy usage in an engaging and playful manner using the programmable Minecraft software with our modification kit. The application of the game contributed to the development of students' STEAM skills (such as complex scientific thinking, logical reasoning, problem-solving, environmental consciousness, systemic thinking, cooperative, collaborative, and independent work).

Students had the opportunity to learn, plan, and construct renewable energy-based facilities, including solar, wind, and hydro power plants, as well as green alternatives like fission-based nuclear reactors (Fig. 1). They gained insights into urban development, including the concept of a sustainable, green city model. The camp also played a role in enhancing critical infrastructure development and fostering a security-conscious mindset, which is indispensable for sustainability.

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DAY 1 Electric Current	DAY 2 Water and Wind Energy	DAY 3 Solar Energy	DAY 4 Nuclear Energy	DAY 5 Szalkszentmárton (Solar Park)
• **Welcome** • **Lecture** - foundational concepts with real-life applications • **Modeling** • Questionnaires • **Minecraft session** - building house and construction of the infrastructure • **Electronics lab** - soldering practice, and a circuit testing exercise • Free game	• **Lecture** - basic concepts and their connections to real-life scenarios • **Modelling** • **Illustration** - direct current in Minecraft • Discussing the unpredictability and inconsistency of water and wind energy • **Minecraft session** - operation of an ME system, crafting, mini-game, reward • **Repair and troubleshooting** of a wind and water energy facility • Quiz • Free game	• **Lecture** - basic concepts and their connections to real-life scenarios • Hydrogen batteries, night-time electricity, relationship with capacitors, direct current storage • **Modelling** • **Minecraft session** - restoration of an island and the exploration of a solar farm • **Repairing** solar panels • **Electronics lab** - dice roller with programming and LED flashing skills, solar panel integration, final test	• **Lecture** - basic concepts and their connections to real-life scenarios • **Modelling** - Operation of the Paks Nuclear Power Plant • **Minecraft session** - restoration and possibly upgrading of a reactor, which hints at a potential backstory for an evacuated island. • **Exercise** - safety measures and other necessary actions. Informational practice • Quiz • Free game	• A visit to a solar power plant - a trip to the site • **Viewing** solar panels and **comparing** them with solar panels installed in Minecraft • **Comparing** the operation of a solar farm with the solar power generation in Minecraft • Free game

Fig 1. Themes of the camp

The opportunity exists to inspire the next generation of thinkers, innovators, and problem solvers capable of tackling the complex challenges facing the world.

The opportunity was taken to adapt the game to the needs of each specialty and create a simulation close to real life. Minecraft is a highly adaptable software that can easily be used not only as a game but also as an educational tool. Mods add elements, valuable functions, and a new world generator to the game. In multiplayer mode, through a central server, students can participate in projects together at the same time, just like in real life. Moreover, by using these game-changing mods, they could get a very realistic picture of the taught fields of science.

For the first time, participants encountered a pre-generated and revised virtual archipelago. The developers have built the campers' plots and houses, and the primary road network. The area of the power plants to be built later was also designated, thus ensuring the dynamics and continuity of the camp concept.

It should be noted that the supply of trees in the archipelago was very low at the beginning of the camp, indicating the need for the creation of afforestation programs by the campers.

Campers carried out the necessary preparations for energy sources or power plants, i.e. the construction of the basic infrastructure: landscaping, procurement of raw materials, construction of additional road networks, and connection of the electric transmission line to the network (Fig. 2.). Speed of intervention, speed of transport, improving the quality of the journey and accessibility of the island were key considerations, so a special underground rail network was built by the campers.

On the fifth (last) day of the camp, a power plant or power park utilising renewable energy sources and alternative energy sources was located at each pre-designated installation point, which is a credit to the campers since they built and designed the various objects using the technologies from the first foundation stone.

Fig. 2 Road networks, and connection of the electric transmission line to the network by campers.

Students also prepared a part of the electrical network created in Minecraft in a practical lab session by installing a solar energy source, as the theme of the camp shows (Fig. 1). On the last day of the camp, the participants could take part in an excursion as per the theme (Fig. 1), where they could visit a solar park so they could compare the solar park built in Minecraft with a real and actively producing park, thus creating a learning chain and connecting the technology created in the virtual space, the in reality, with a faithful significant other.

The exceptional nature of the constructed Minecraft camp stemmed from the developers' incorporation of 50 game- modifying mods, thereby providing the children with a virtual experience that closely approximated or authentically mirrored real-world scenarios. This innovative approach allowed the students to interact with the game in a manner that enhanced their understanding of complex concepts while fostering a deeper engagement with the educational content.

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5 Evaluation of the innovative educational experiment

Feedback on the method used in the camp was aimed to be collected through questionnaires. It was considered essential to obtain feedback from the participating students to continuously improve the concept and methods of the camp. On the first and last day of the camp, questionnaires were filled out by the students to disclose their current knowledge about renewable energy sources. The collaboration and the "climate" of the camp were also assessed with questionnaires. In the research, it was hypothesized that the Minecraft method is equally effective regarding knowledge acquisition and collaboration.

5.1 The measurement tools

The questionnaire on renewable energy sources contained ten multiple-choice questions to assess the student's current level of knowledge. The researchers used a self-developed set of questions to assess the background variables, examine expectations and experiences related to the camp, and reveal opinions about Minecraft's use.

To examine collaboration, the "collaborative skills questionnaire" [42] was used, through which feedback was received on the social competence of students in group problem-solving situations and their ability to cooperate with peers.The respondents filled out an 18-item self-assessment questionnaire, in which they evaluated each statement on a 7-point scale, which was aimed at measuring social skills (e.g. action, interaction, effort, adaptive responsiveness, matching behaviour to the partner's needs, negotiation, self-evaluation, peers assessment, responsibility). The listed sub-skills comprised three more prominent skill elements: participation, perspective-taking and social regulation.

Creativity research in education emphasises the importance of creating a creative ecology in sociocultural formations of digitally networked cultures and collaborative thinking methods. The goal is to foster greater creativity in education systems by attending to increasing creative sociality within and between diverse cultures and contexts [43]. To explore the characteristics of the camp, the "school creative climate questionnaire" was adapted [44] to explore the environmental factors that measure creativity. The questionnaire contains 47 statements, which form five dimensions: group atmosphere, re-opening, encouraging diversity, autonomy, challenge, interest and limitations, and pressure. Here, too, the respondents evaluated the individual statements on a 7-point scale.

5.2 Camp participants

Fifteen students participated in the camp: 1 girl and 14 boys, with an average age of 11.6 years (ranging from 10 to 16 years). All completed the questionnaires to facilitate examination of the camp's effectiveness. The camp students were familiar with the world of computer games. Of these, 33% spent 1-2 hours a day playing computer games, 40% spent 2-3 hours, 13% spent 4-5 hours, and 7% spent more than 5 hours. Only 7% of the respondents played less than an hour a day.

5.3 Results

The analysis of the questionnaires revealed that students came to the camp with specific expectations. They primarily expected the camp to have fun during the camp (on a 4-point scale, average: 3.73), to spend their time usefully (average: 3.60), to take part in exciting laboratory activities (3.67), and to play together and learn about with other students (3.60). The camp met these initial expectations. Based on the student feedback, that the students had fun during the camp (3.87), spent their time usefully (3.80) and played and learned together (3.80) was found. In other words, the method used contributed to making learning an experience for them so that the users' free time is connected to the learning process.

In all but two cases, the average score on the last day's questionnaire was higher than the first. Participants had hoped for more from their visit to the photovoltaic power station, and the experience of the lab sessions was precisely what they had hoped. The most tremendous improvement over expectations was the new friends the students made at the camp (Fig. 3)

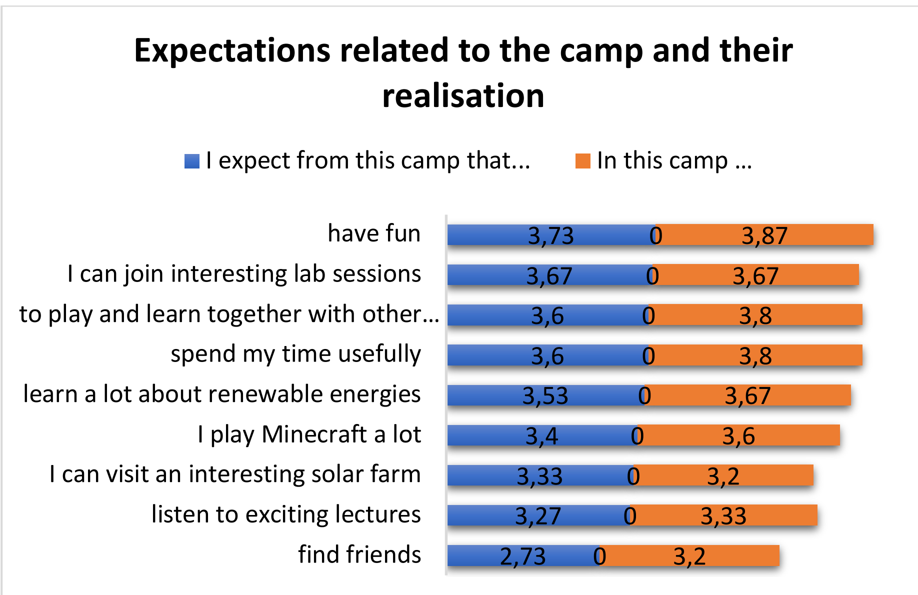

Fig. 3. Expectations related to the camp and their realisation (evaluation on a 4-point scale, N=15)

Results of the knowledge level assessment questionnaire taken on the first and last day of the camp proved that the students learned effectively in this playful form. Practical and topical questions about knowledge about renewable energy made the students think (e.g. what consumes the most electricity in an average Hungarian home, how much electricity does a Hungarian home consume on average in a year, what uses more energy: the laptops (6 hours) use or making coffee with the coffee machine (15 minutes).

After the measurements, that students' knowledge levels increased during the camp: on the first day, the percentage of correct answers was 47.33%, and on the last, it was 56%. Regarding the individual questions, the percentage of correct answers was 47.33% on the first day and 60.67% on the last. The rate of improvement for individual campers is 8.67%, and 13.33% for each question were found.

The camp contributed to learning about renewable energy and playfully raising environmental awareness using modern technical equipment. Participating students learned about the potential of renewable energy sources, energy consumption, energy awareness and energy efficiency.

The Minecraft world was well known to the students even before the camp. 86.67% of them used to play Minecraft at home, 27.67% at a friend's, relative's or acquaintance's house, and 6.67% at school, in a lesson, or in a professional circle (some respondents have already played in several locations). Before the camp, every child knew this game.

In the questionnaire taken on the first day of the camp, the participants answered that what they like most about Minecraft is that it provides good relaxation (on a 4-point scale, average: 3.73), that they can realise their ideas in it (average: 3.67), and that you can play together with others (average: 3.6). In education, these motivational factors can be used to the best advantage, so students can solve different tasks in a playful environment while being creative and able to cooperate with their peers.

The tremendous success in the camp was the large-scale and experience-influencing modification expansion because by transforming the basic game, the children felt the game had gained a new meaning. They liked that they could solve tasks (average: 3.87), and this game gave them good relaxation (average: 3.87).

The most significant positive difference between the initial experience with Minecraft and the application in the camp can be seen in the fact that they were better able to solve tasks, learned more from it and got to know better how to model the real world. (Table 1).

To further evaluate the applied method, adapted to the "school creative climate questionnaire" [44] according to the characteristics of the camp. (The questionnaire proved reliable; the value of Cronbach's alpha is 0.90.)

The respondents considered it highly optimistic that the teachers at the camp were interested in what the students thought about a topic (average: 6.73 on a 7-point scale), that they encouraged them to find new solutions (average: 6.60), and they felt, that learning in the camp made sense (average: 6.47) because they learned a lot of exciting things by searching for new solutions (average: 6.60). Minecraft created a perfect opportunity to focus attention on students, playful learning, support of innovations, problem-solving and support of students' ideas in the teaching-learning process. The method helped create an open, supportive atmosphere and thus made learning more effective.

Table 1. Evaluation of Minecraft's software possibilities (on a 4-point scale, N=15)

	What I love about Minecraft is that…		What I liked about Minecraft during the camp was that		The difference between the means
What I love about Minecraft is that…	**Average**	**SD**	**Average**	**SD**	
you can play together with others	3.60	0.83	3.53	0.92	-0.07
you can build a new world of your own	3.40	0.74	3.67	0.72	0.27
I can realise my ideas in it	3.67	0.62	3.47	0.74	-0.2
the graphics are good	2.87	1.13	3.20	0.94	0.33
you can learn a lot from it	2.93	0.88	3.40	0.91	0.47
I can solve tasks	3.13	0.92	3.87	0.35	0.74
provides good relaxation	3.73	0.46	3.87	0.35	0.14
it models the real world	2.80	1.01	3.20	0.94	0.4
Minecraft takes on a whole new meaning with so many modes.			3.93	0.26	

The statements of the creative climate questionnaire are organised along five dimensions [44]. In the camp using the game Minecraft, the dimension of openness was the strongest, which means that the camp supported the students to be open to new things, to examine emerging questions from a new approach, and to try new things. The camp was a challenge for the number of students and limited them little in their autonomy and time. (Fig. 4)

The second dominant dimension is the challenge; that is, the use of Minecraft was challenging for the participants. Because the students felt that they were learning important, exciting and meaningful things, they became more and more motivated and did not get bored. This subscale also refers to the meaningfulness of tasks and commitment to goals.

Group trust and support came in third place, i.e. how much acceptance there is between group members, whether mutual attention is realised, and whether help and cooperation are typical. The use of the Minecraft method contributed to the creation of an atmosphere of trust in the community.

Encouragement also played an essential role in the camp. The method has proven to encourage students to be open-minded and take risks. The students were allowed to look at the field of renewable energy sources from a new perspective, look for alternative solutions, and formulate new ideas without any punishment for making a mistake. By using Minecraft, it was possible to create an atmosphere that encourages students to try various intellectual and creative endeavours and to be open to new things.

The dimension of limitations, on the other hand, receded into the background at the camp, meaning that the students had a great deal of opportunity to make their own decisions and were not limited by the instructors in completing their tasks. In this way, the method contributed to independent decision-making and independent task performance.

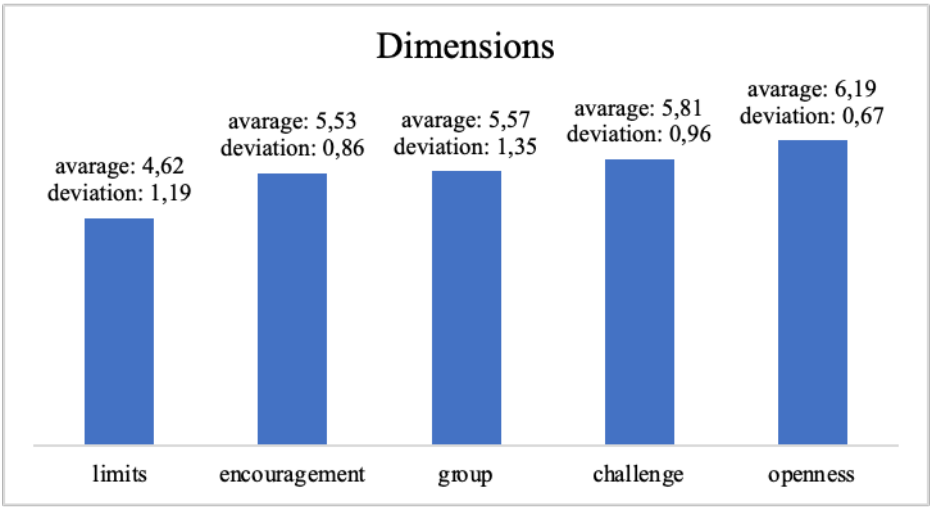

Fig. 4. Dimensions of the camp's creative climate (N=15)

The use of Minecraft also could provide an excellent opportunity for collaboration, which the researcher team used the "collaborative skills questionnaire" [36]. The questionnaire measures how students can cooperate with their peers in group problem-solving situations. (When examining the reliability of the questionnaire, Cronbach's alpha value was 0.91 for the questionnaire on the first day and 0.85 for the questionnaire on the last day).

On the first day the trainers asked the participants to recall situations in which they had to solve some class or extracurricular task or project in pairs or in larger groups and then try to determine how typical the given statements were for them in these situations. The most characteristic of the respondents is that when they work in a group work, they usually try to solve their partial task until they succeed (average: 6.20 on a 7-point scale), and they try another strategy to solve their partial task if the previous one did not work (6 .07) and respond to others' suggestions (average: 6.00).

The data of the questionnaire taken on the last day of the camp revealed that the participants know what kind of work they are best suited for (average: 6.02), they try to solve their tasks until they succeed (average: 6.00), and they can easily see if they are not suitable (average: 6.00).

The most significant positive difference in the assessment of the previous group work and the group work in the camp can be seen below: in the camp, the students made more suggestions about what task to do (difference: 0.73), they found a familiar voice with everyone (difference: 0.67), and they shared their ideas better with their peers (difference: 0.53).

The camp allowed them to be more open to their peers and work with them better. The tasks provided space for formulating and sharing one's ideas, as well as for thinking together.

The questionnaire's statements on collaborative abilities form three subscales, and the data of a large sample (N=2128) taking place in the eighth grade can be used as a basis for comparison [42]. (Since only one girl participated in the camp, a gender comparison was not performed. This was not by design but a limitation based on the participants available and willing to participate.)

The Participation subscale shows how much a student is involved in the work, how he/she responds to peer initiatives, whether he/she initiates interactions, and how much effort he/she puts into a given group task.

The Perceptions subscale measures whether the student is open to suggestions from teammates, whether the student can shape his/her communication in a way that others can accept, and whether the student is receptive to the needs of other students.

The Social Regulation subscale gives feedback on the extent to which the learner can make compromises, whether he/she can assess his/her own strengths and weaknesses and keep them in mind when choosing a task in the group. Does he or she see the abilities of others and take them into account when assigning and carrying out tasks, and does he or she feel personally responsible for ensuring that his or her group completes the task [42]?

In the Minecraft camp, significantly higher scores were obtained than in the previous large sample study, which indicates that the participants in the camp were characterised by harmonious cooperation, the students made efforts to solve tasks, and they were open to the ideas and suggestions of their peers. They felt personal responsibility for the group solving the set tasks.

Upon examining the post-camp questionnaires, we observed a statistically significant enhancement in collaborative skills, with the average score increasing from 97.80 (SD = 17.62) to 98.87 (SD = 14.68). This increment, albeit marginal, is statistically relevant and indicates an effective intervention in reinforcing teamwork competencies through the camp activities. The data, particularly the improved point-of-view and social regulation subscales, reflect a refined group dynamic and suggest that our Minecraft-based approach positively influences collaborative processes (Table 2).

In contrast, the slight reduction in the participation subscale average from 35.40 (SD = 6.09) to 34.47 (SD = 3.70) signals a potential area for pedagogical refinement. This warrants a methodological adjustment to bolster individual engagement, which is a cornerstone of active learning and crucial for the holistic development of STEAM competencies (Table 2).

Comparatively, our intervention's outcomes, when juxtaposed with the normative findings by Pásztor-Kovács et al. (2020), demonstrate a superior facilitation of collaborative skills through the immersive Minecraft environment [42]. This suggests that the gamification of educational content could be instrumental in enhancing engagement and collaboration among learners in STEAM education. Future applications of this pedagogical strategy should consider integrating systematic reflections and adaptive challenges to foster both collective and individual student participation (Table 2).

Table 2. Comparative study of collaborative abilities (own research: N=15, research by Pásztor-Kovács et al.: N=2128)

	Group work in general (day 1)		Group work in the camp (last day)		Study by Pásztor-Kovács et al. (2020)	
	Average	SD	Average	SD	Average	SD
Collaborative skills (full scale)	97.80	17.62	98.87	14.68	boy: 86.91 girl: 89.95	boy: 17.30 girl: 16.43
Participation subscale	35,40	6.09	34.47	3.70	boy: 29.45 girl: 30.96	boy: 6.60 girl: 6.43
Point-of-view subscale	20.40	3.62	21.20	3.61	boy: 19.34 girl: 19.97	boy: 4.33 girl: 4.20
Social regulation subscale	42.00	9.46	43.20	9.44	boy: 38.13 girl: 39.02	boy: 7.86 girl: 7.61

6 Conclusions

The modified use of Minecraft software can be seen as an innovative educational methodological tool that allows students to acquire knowledge and skills in an important and complex scientific field such as the environment in a playful way. The applicability of Minecraft in education was tested within the framework of a summer university camp. The study presented the development possibilities of Minecraft and the experience of its application. Through this unique educational endeavor, we explored how the enhanced Minecraft's interactive and immersive environment can revolutionize learning, providing students with a creative, engaging, and effective platform for acquiring essential knowledge and skills. By harnessing the power of this virtual world, the aim is to inspire educators and learners alike to embrace new and exciting methods of education that foster a love for learning and a deeper understanding of complex subjects. During the camp, students built a Minecraft island world where renewable energy sources powered their city. The power plants were built and constructed. The approach is unique because more than 50 game modifications were added to the basic game, giving children a virtual experience close to reality. To assess the effectiveness of the camp and the method used, questionnaires were conducted on the first and last day. These were primarily aimed at revealing the current level of knowledge about renewable energy sources, the collaboration taking place in the camp, and the "climate" of the camp. The data analysis suggested that the camp was successful in supporting students' knowledge acquisition and collaboration. The reimagined Minecraft software aroused the students' interest and increased their motivation and activity; thereby, they learned the material more effectively and could cooperate with their peers. The results of the Minecraft camp can also be used in education, for example, in the fields of STEAM (Science, technology, engineering, arts and mathematics). Students often struggle to learn science subjects, but they can learn the curriculum by playing with the Minecraft software. Game-based learning creates an opportunity for learning to become an experience, for students to participate more actively in the learning process, gives space to their creativity and creates opportunities for collaboration.

Minecraft has various connections with the different fields of education and engineeringhttps://doi.org/10.3991/ijep.v9i1.9948. It can be used as an educational tool to teach subjects such as math, science, and renewable energy, as well as basic engineering concepts. Furthermore, the game's modding environment allows students to learn programming and game development skills, problem-solving, critical thinking, and design thinking, which can be applied to a career in engineering or computer science [45].

References

1. Breuer, J. S. & Bente, G.: Why so serious? On the relation of serious games and learning. Eludamos. Journal for Computer Game Culture, 4(1), pp. 7-24 (2010)
2. Dewey, J. & Dewey, E.: Schools of tomorrow. EP DUTTON & COMPANY, New York (1915). https://www.gutenberg.org/files/48906/48906-h/48906-h.htm
3. Csíkszentmihályi, M.: Flow - The Psychology of Optimal Experience. Harper & Row, New York (2008)
4. Faizan, ND, Löffler, A., Heininger, R., Utesch, M., & Krcmar, H.: Classification of Evaluation Methods for the Effective Assessment of Simulation Games: Results from a Literature Review. International Journal of Engineering Pedagogy (iJEP), 9(1), pp. 19–33 (2019).
5. Liddle, M.: Teaching the unteachable handbook on group facilitation. Pressley Ridge Hungary Foundation (2008)
6. Fischer, H., Heinz, M., Schlenker, L., Münster, S., Follert, F. & Köhler, T.: Die Gamifizierung der Hochschullehre – Potenziale und Herausdorfen. In: Strahringer, S., Leyh, C. (Eds.) Gamification and Serious Games. Edition HMD. Springer Vieweg, Wiesbaden (2017). https://doi.org/10.1007/978-3-658-16742-4_9
7. Puritat, K.: Enhanced Knowledge and Engagement of Students Through the Gamification Concept of Game Elements. International Journal of Engineering Pedagogy (iJEP), 9(5), pp. 41–54 (2019). https://doi.org/10.3991/ijep.v9i5.11028
8. Torres-Linke, M., Neumann, M., Zielbauer, M, Drieschner, C., Utesch, MC & Krcmar, H.: Promoting movement and strengthening arithmetic performance through gamification - The development of an IT-based learning app. 2022 IEEE Global Engineering Education Conference (EDUCON), pp. 1829-1838 (2022). https://doi.org/10.1109/EDUCON52537.2022.9766677.
9. Quian, M. & Clark, R.: Game-based Learning and 21st century skills. Computers in Human Behavior, 63(10), pp. 50−58. (2016) https://doi.org/10.1016/j.chb.2016.05.023
10. Módné, TJ, Pogátsnik, M. & Kersánszki, T .: Improving Soft Skills and Motivation with Gamification in Engineering Education. In: Auer, ME, Hortsch, H., Michler, O., & Köhler, T. (Eds.) Mobility for Smart Cities and Regional Development - Challenges for Higher Education: Proceedings of the 24th International Conference on Interactive Collaborative Learning. Cham: Springer International Publishing, pp. 823-834 (2022) https://doi.org/10.1007/978-3-030-93904-5_81

11. Duchon, J.: Tools for gamification of an e-learning course in Moodle LMS system. In: Tóth, P., Simonics, I., Manojlovic, H., Duchon, J. (Eds.): New challenges and pedagogical innovations in vocational training and higher education. Óbuda University, Budapest, pp. 407-420 (2018)
12. Rigóczki, Cs., Damsa, A. & Györgyi-Ambró, K.: Gamification on the edge of educational sciences and pedagogical methodologies. Journal of Applied Technical and Educational Sciences, 7(4), pp. 79-88 (2017)
13. Utesch, MC: The Pupils' Academy of Serious Gaming: Strengthening Study Skills. International Journal of Engineering Pedagogy (iJEP), 5(3), pp. 25–33 (2015). https://doi.org/10.3991/ijep.v5i3.4660
14. Sanda, ID: New Forms of Pedagogical Assessment in Engineering Teacher Education. In: Auer, ME, Pachatz, W., Rüütmann, T. (eds) Learning in the Age of Digital and Green Transition. ICL 2022. Lecture Notes in Networks and Systems, vol 634. Springer, Cham (2023). https://doi.org/10.1007/978-3-031-26190-9_36
15. Molnár, Gy., Orosz, B. & Nagy, K.: Current Issues and Possible IT Solutions for Digital Competence Development. In: Turčáni; M., Balogh, Z., Munk, M., Magdin, M., Benko, L. & Francisti, J. (Eds.). DIVAI 2022, 14th International Scientific Conference on Distance Learning in Applied Informatics. Wolters Kluwer, Párkány, pp. 267-27. (2022)
16. Molnár, Gy. & Nagy, K.: Digital competencies of teachers in the digitalising education sector and in the smart learning environment . In: Szakál, A. (Eds.) IEEE 20th Jubilee International Symposium on Intelligent Systems and Informatics (SISY 2022) . IEEE, Subotica, pp. 325-330 (2022) https://doi.org/10.1109/SISY56759.2022.10036290
17. Prensky, M.: Fun, Play and Games: What Makes Games Engaging. New York: McGraw-Hill (2001)
18. Renninger, KA, & Bachrach, JE: Studying triggers for interest and engagement using observational methods. Educational Psychologist, 50(1), pp. 58–69 (2015). http://doi.org/10.1080/00461520.2014.999920
19. Whitton, N.: The place of game-based learn-ing in age of austerity. Electronic Journal of e-Learn-ing, 10(2), pp. 249−256. (2012).
20. Gee, J. P.: A sociocultural perspective on opportunity to learn. In P. A. Moss, D. C. Pullin, J. P. Gee, E. H. Haertel, & L. J. Young (Eds.), Assessment, equity, and opportunity to learn. pp. 76–108 Cambridge University Press (2008). https://doi.org/v
21. Gee, J. P.: Reflections on empirical evidence on game and learning. Ed. S. Tobias & J. D. Fletcher. Computer Games and Instruction p. 223-233 Charlotte, NC: Information Age Publishers (2011)
22. Malone, T. W. & Lepper, M. R.: Making learning fun: A taxonomy of intrinsic motivations for learning. Aptitude, learning, and instruction, 3, pp. 223-253 (1987)
23. Sánchez, LI, Roig-Vila, R., Amor, PR.: Metaverse and education: the pioneering case of Minecraft in immersive digital learning. El Profesional de la Informacion 31(6) pp.1699-2407 (2022). https://doi.org/10.3145/epi.2022.nov.10
24. Dezuanni, M.:, Children's digital play and socio-material literacy practices, The Routledge Handbook of Digital Literacies in Early Childhood , Edition 1st Edition First Published (2019)
25. Yi, S., Gadbury, M., & Lane, HC: Identifying and Coding STEM Interest Triggers in a Summer Camp. In de Vries, E., Hod, Y., & Ahn, J. (Eds.), Proceedings of the 15th International Conference of the Learning Sciences - ICLS 2021. pp 915-916 Bochum, Germany: International Society of the Learning Sciences (2021)
26. Hughes, BE, Willoughby, SD, LaMeres, BJ, Frank, B., Westbrook, EM, & Lux, N.: Gaming Spatial-Skill Development: Building STEM Pathways with the Use of the

Minecraft Gaming Platform Paper presented at 2020 ASEE Virtual Annual Conference Content Access, (2020). 10.18260/1-2—34698

27. March, J., The internet of toys: A posthuman and multimodal analysis of connected play Teachers College Record Volume 119, Issue 12. Article number 6. (2017) https://doi.org/10.1177/016146811711901206
28. „Must-Know Minecraft Statistics [Recent Analysis] • Gitnux". (Sources: 12. 04. 2024) [Online]. https://gitnux.org/minecraft-statistics/
29. „Minecraft User Statistics: How Many People Play Minecraft In 2024?" (Sources: 04. 12. 2024) [Online]. https://www.searchlogistics.com/learn/statistics/minecraft-user-statistics/
30. Dezuanni, M., Multiliteracies and Early Years Innovation: Perspectives from Finland and Beyond, pp. 183–198, (2019) https://doi.org/10.4324/9780429432668-11
31. Bourdeau, S., Coulon, T., & Petit, M.-C.: Simulation-Based Training via a "Readymade" Virtual World Platform: Teaching and Learning With Minecraft Education. IT Professional, vol. 23, no. 2, pp. 33-39 1 March-April (2021). https://doi.org/10.1109/MITP.2021.3062935
32. Klimová, N., Šajben, J., & Lovászová G.: Online Game-Based Learning through Minecraft: Education Edition Programming Contest. 2021 IEEE Global Engineering Education Conference (EDUCON), pp. 1660-1668. (2021). https://doi.org/10.1109/EDUCON46332.2021.9453953
33. Short, D.:Teaching Scientific Concepts using a Virtual World – Minecraft. Teachingscience, 58(3), pp. 55-58. (2012)
34. Goldberg, D. & Larsson, L.: Minecraft. The Unlikely Tale of Markus "Notch" Persson and the Game that Changed Everything. New York – Oakland: Seven Stories Press (2011)
35. Shaw, A.: Creative Minecrafters: Cognitive and personality determinants of creativity, novelty, and usefulness in Minecraft. Psychology of Aesthetics Creativity and the Arts . (2022) https://doi.org/10.1037/aca0000456
36. Voštinár, P., & Dobrota, R. : Minecraft as a Tool for Teaching Online Programming, 2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO), pp 648-653 (2022) https://doi.org/10.23919/MIPRO55190.2022.9803384
37. Wössner, S.: Immersive Intercultural Language Learning at the Crossroads of Virtual Reality and Game-Based Learning. In *Immersive Education: Designing for Learning*, pp. 71-87. Cham: Springer International Publishing (2023) https://doi.org/10.1007/978-3-031-18138-2_5
38. Horsten, M. J.: What did I just learn? How commercial video games could underhandedly teach players environmental sustainability (Dissertation) (2022). http://urn.kb.se/resolve?urn=urn:nbn:se:hj:diva-57754
39. Alam, A., & Mohanty, A.: Metaverse and Posthuman Animated Avatars for Teaching-Learning Process: Interperception in Virtual Universe for Educational Transformation. In International Conference on Innovations in Intelligent Computing and Communications, pp. 47-61. Springer, Cham (2022) https://doi.org/10.1007/978-3-031-23233-6_4
40. Costafreda Mustelier, JL., Peña Narciso, C., Herrera Herbert, J., Westrin, P., Luque, F., Piovano, L.: Bettergeoedu: the use of minecraft as an interactive tool to facilitate the knowledge on rocks and minerals in primary school students. In: "15th International Technology, Education and Development Conference", 8-9 Marzo, (2021). ISBN 978-84-09-27666-0. https://doi.org/10.21125/inted.2021.0472.
41. Salmi, H., Thuneberg, H., Bogner, F. X., & Fenyvesi, K.: Individual creativity and career choices of pre-teens in the context of a Math-Art learning event. Open Education Studies, 3(1), pp. 147-156 (2021) https://doi.org/10.1515/edu-2020-0147

42. Pásztor-Kovács, A., Pásztor, A., & Molnár, Gy.: A csoportmunkához szükséges képességek vizsgálata: a kollaboratív képességek kérdőív validálása [Examining the skills required for group work: validation of the collaborative skills questionnaire]. Magyar Pedagógia [Hungarian Pedagogy], Vol. 120, No.1. pp. 269–296 (2020) https://doi.org/10.17670/MPed.2020.3.269
43. Harris, A.M., de Bruin, L.: Creative Ecologies and Education Futures. In: Mullen, C.A. (eds) Creativity Under Duress in Education? Creativity Theory and Action in Education, vol 3. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-90272-2_6
44. Péter-Szarka, Sz., Tímár, T., & Balázs, K.: Az iskolai kreatív klíma kérdőív [The school creative climate questionnaire]. Alkalmazott Pszichológia [Applied Psychology], Vol. 15. No. 2. pp. 107–132 (2015)
45. Fazekas, Á. (ed.); Fazekas, Á.; Halász, G.; Horváth, L.; Pálvölgyi, L.; Balázs, É.; Antoni-Alt, P.: Innováció az oktatásban [Innovation in Education] Budapest, Akadémiai Kiadó (2021) https://doi.org/10.1556/9789634547143 ISBN: 9789634547143