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## MINECRAFT: A REMOTE LABORATORY FOR GAME-BASED DISTANCE LEARNING

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### Abstract

Immersive learning environments are some of the technological and cognitive artifacts that can support active teaching approaches, in which product and process evaluation can sustain significant learning even in remote contexts, if well designed and calibrated for the students in training. The paper delves into the experience of remote laboratory teaching conducted within the MineClass project between 2018 and 2021, during which the pandemic school saw a reduction at a national level of active and collaborative laboratory activities due to social distancing, both in-person and remotely. The study integrates results from case studies, qualitative and quantitative surveys, and semi-structured interviews directed at participants in the experimentation. Within the larger primary sample, a follow-up questionnaire was administered in 2022 with the aim of exploring the didactic use of the video game during the pandemic years; most respondents reported continuing laboratory teaching activities with Minecraft even to support distance learning after the conclusion of the MineClass project. The results show the positive impact of the experimentation in terms of perceived added value by teachers for the development of cross-cutting competences, increased motivation, involvement, and autonomy of their students.

### Keywords:

Laboratory-based Teaching, Immersive Learning, Distance Learning, Minecraft.

### Laboratory teaching during the pandemic

The years of the pandemic represented a period of deep crisis for Italian schools: the health emergency caused a situation of strong uncertainty and schools found themselves operating in a context of unprecedented and constantly evolving challenges. With the suspension of in-person teaching activities and the introduction of distance learning, new difficulties but also precious opportunities emerged for a general rethinking and renewal of teaching and organizational practices (Carretero Gomez et al., 2021; CENSIS, 2020; Sun, 2020).

The restrictive measures forced experimentation with new approaches, tools, and learning environments, and this became particularly necessary for those subjects and disciplines that 'prefer' laboratory activities. The closure of institutions, the interruption of in-person teaching, and the inability to access school laboratories have had a greater impact on collaborative learning processes and on those teaching activities based on doing, physical manipulation, and peer interaction.

Internationally, a considerable number of schools and universities, to ensure the continuation of distance laboratory teaching, have adopted mixed and/or online modes of laboratory delivery (Gamage et al., 2020). Unfortunately, in our country, teachers prepared for distance learning were a "small minority" and this may have exacerbated that "destabilizing uncertainty" (Perla & Riva, 2016) produced by the interruption of traditional teaching methods and the need to necessarily reorient their actions (Mezirow, 2016). At the same time, the unprecedented situation in which they found themselves operating has certainly renewed reflection on the

meaning, purposes, and methods of their teaching practice (Tramma, 2018). But in Italy this rethinking has not always translated into concrete actions and practices of renewal.

From surveys conducted during the lockdown period (INDIRE, 2020a; 2020b; 2021; SIRD, 2020), it emerges that teachers have rarely modified their methodological and didactic approaches and that a particularly high proportion has used, even during distance learning, frontal teaching and a traditional/transmissive style, rarely exploiting the potential offered by active methodologies (Ianes & Bellacicco, 2020). In the majority of cases, the typical practices of in-person teaching were transposed to distance learning (SIRD, 2021; INDIRE, 2020a; 2020b; 2021), leaving little room for that crucial passage towards the development of competencies and learning objectives, required even in the National Guidelines (MIUR, 2012) and for laboratory teaching that ensures that knowledge, skills and competencies are consciously put into action (Cigognini & Di Stasio, 2022).

While frontal lessons have essentially been transformed into live synchronous video conferences and asynchronous streaming, the problem has arisen for those courses characterized by practice-oriented activities that require teacher-student interaction and significant use of laboratory tools. The online approach, e-learning tools, and distance learning methods work very well for knowledge construction through content delivery and process supervision but have limitations in the development of practical laboratory skills. Research shows, however, that student learning outcomes in remote labs are equal and sometimes better than traditional labs (Byukusenge et al., 2022; Fadda & Vivonet, 2021; Rubim et al., 2019; Post et al., 2019), because they provide a more collaborative learning environment thanks to the higher level of interaction between students and teachers compared to in-person labs (Gamage et al., 2020).

### **Minecraft in Education**

Minecraft is a 3D first-person sandbox videogame. In English, the term "sandbox" refers to the typical sandbox enclosure intended for children's games. Sandbox-type video games provide the player with a (digital) place to move freely and digital tools to modify it. In a sandbox videogame, the perimeter of the enclosure is much larger than physical sandboxes, and both the materials available and the tools for working with them change; one can think of it as a kind of digital LEGO® evolution. The substantial differences are that in Minecraft: you find yourself building inside a 3D world generated by the computer, with seas and mountains, trees, and animals; you are mediated by an avatar, a graphical representation of the player who acts in the game world at their command and signals to any other players (who are also mediated by an avatar) their presence and position in the game. The player sees the game world through their avatar's eyes.

To date, Minecraft is the most popular game in the world, with over 280,000,000 licenses sold, and for some years, examples of its use in school education have been seen. According to Cipollone et al. (2014), Minecraft offers students a unique opportunity to show their creativity and promote the understanding of concepts in ways that are more feasible than experiential learning in the real world. The use of Minecraft runs through the curriculum from STEM (Lane et al., 2017) to the Arts (Cayatte, 2013) and is also used in informal contexts, such as the development of socio-emotional skills (Ringland et al., 2016). With the increasing attention from schools, there has also been an increase in the production of texts that guide teachers in adopting Minecraft in their classroom teaching (Gallagher, 2014; Dikkers, 2015).

### **The MineClass Course**

MineClass was an online training and experimentation course organized by The National Institute For Documentation, Innovation And Educational Research (INDIRE) in collaboration with Microsoft intended for primary and secondary school teachers, with the aim of training them in the didactic use of Minecraft. The first edition of MineClass started in December 2018 and ended in June 2019. Given the interest shown by teachers, the course was subsequently replicated in two additional editions, in the 2019/20 and 2020/21 school years. In total, the MineClass course trained more than 300 teachers over the three editions. The MineClass training, rather than on the functioning of the software, focused on the acquisition, by teachers, of a specific didactic methodology, developed by the researchers together with a group of teachers and strongly inspired by the principles of Design Thinking (Brown, 2008). This methodology provides that:

- the activity of building in Minecraft by students is always preceded by paper planning, so that the action (building) always depends on a declared plan on paper, and that problems are addressed first in the definition, ideation, and planning stages, even before implementation;
- students are left with a good degree of autonomy in their activity. One of Minecraft's strengths is that it allows students to unleash their creativity and initiative. Classroom teaching activities should therefore tend towards a balance between constraints (necessary to guide students and prevent the activity from getting out of control) and degrees of freedom (which allow them to be creative and autonomous in their decisions);
- students work in teams (small groups of 3, 4, at most 5 students). Within the team, each student has a different role/responsibility.

Based on these and other indications, each participating teacher in the MineClass course was asked to design their own teaching activity based on their teaching discipline, incorporating it into the curriculum, and then experiment with it in class with their students during the training period. INDIRE conducted a study on the MineClass course to verify the conditions necessary for the teacher to implement effective and sustainable teaching activities that integrate the use of Minecraft in classroom teaching, such as training, support, materials, prior experiences, and the didactic-organizational context (Benassi et al., 2021).

### **Minecraft from Remote**

Of the three editions of the MineClass course, the last two were strongly influenced by the pandemic.

In the 2019/20 edition, the lockdown occurred halfway through the course, when the participating teachers had already designed their teaching activity and were about to experiment with it in class. With schools closed, most of the teachers in that edition were unable to carry out the experimentation. However, some of them tried to redesign the activity so that it could be done by students (and the teacher) from home, using the potential of Minecraft as an online multiplayer platform. Minecraft, in fact, in its Education Edition version, allows the teacher to launch a game world on their computer and open it to other users connected remotely (Benassi et al., 2021 p. 112). In this way, students can access the game world made available by the teacher and work together under their supervision.

In the 2020/2021 final edition, the schools had been reopened in a strong situation of regional discontinuity throughout Italy, but the rules on social distancing and the continuous threat that, with the worsening of the pandemic situation, schools could be closed again, made it difficult to repeat the MineClass course as it had been conceived before the pandemic, without the necessary corrections. It was therefore decided to limit the registrations to those teachers who declared that they could manage and conduct the experimentation of the activities even in case of school closure, i.e. in "DaD" (Distance Teaching and Learning). As a result, the research applied to the MineClass course also expanded and adapted to be an observatory to accompany teachers and students in their learning paths related to the distance use of Minecraft and to investigate the methods involved.

### **Research Methodology**

This study integrates results from case studies, quanti-qualitative surveys, and semi-structured interviews with participants in the MineClass project, using a mixed-method approach with the integration of quanti-qualitative tools for data collection (Mortari & Ghirotto, 2019; Trincheri & Robasto, 2019). Here the focus is on the results of the last year of the pandemic and the final follow-up.

The research protocol provided a set of quanti-qualitative investigation tools aimed at different subjects in various training phases: teachers were involved through an initial and final questionnaire while students' opinions were collected through a final questionnaire. The measurement tool's validity was construct-validated based on the dimensions of the European DigCompOrg framework, and a pilot study was conducted with a group of experienced teachers to evaluate the consistency of the questions and administration time.

Out of 320 initial enrollees, the 2019/2020 edition had a sample of 169 subjects who completed the classroom experiment, of whom 122 completed all investigation tools (initial and final questionnaires, project analysis,

blog/forum interactions). The 2020/2021 edition saw the participation of 59 teachers who completed training and experimentation on the use of Minecraft for distance teaching during the pandemic. The teachers were involved in an initial and final questionnaire, as well as qualitative analysis of the works produced and the documentation of training activities in the diary blogs.

At the end of the project, a follow-up questionnaire was administered in 2022 to the larger main sample with the aim of deepening the didactic use of the videogame during the pandemic years. 150 out of 237 teachers completed the questionnaire, and most respondents stated that they continued to use Minecraft for distance teaching even after the conclusion of the MineClass project.

The research questions underlying the experimental activities concerned the sustainability and enabling conditions of using Minecraft in their curricular teaching, and how and if the immersive teaching thus prepared could enhance the development of transversal skills of the P21 framework (Mishra & Kereluik, 2021). Specifically, attention is directed towards autonomy, teamwork, and socialization skills.

The diachronic research activities for the three-year period of 2019-2021 have been restructured based on the evolution of the pandemic situation. The forced shift to distance learning has drastically reduced the sample size due to constraints related to connectivity and access to homogeneous distance laboratory teaching for the entire class. The research group has adapted to this situation by implementing a monitoring and observation approach, which includes dedicated meetings, semi-structured online interviews, textual analysis of the projects and blog diaries. Due to school closures, final questionnaires were not administered to teachers and students, as they were already being surveyed by the Indire Distant Teaching and Learning Observatory (Indire 2020a, 2020b).

The statistical analysis carried out focused on the description of all variables using simple and double frequency tables, with data presented and discussed as frequencies and percentages. Data analysis utilized statistical methodologies of univariate and bivariate analysis (Pearson's chi-squared test) for structured questionnaires, and posterior categorization by three independent judges for textual analysis of interviews, focus groups, online forums, blogs, and teachers' works. Below are the results related to the perspective of teachers who have implemented immersive distance teaching.

## Results

The results show the positive impact of the experimentation in terms of perceived added value for teachers in the development of transversal skills, increased motivation, involvement and autonomy of their students. These data are particularly comforting and significant in relation to the unprecedented conditions posed by the pandemic and the forced closure of schools. Above all, Minecraft is perceived by the teachers involved in the follow-up, who have also used it remotely, as a strong element of cohesion for socialization and the reduction of social distancing, despite the initial technological gap that saw a reduction in the classes that could participate in the experimentation, due to technological access conditions. For those who have moved Minecraft to a distance setting, in the distributed and dislocated laboratory in the afternoon, there has been an increase in social well-being aspects in contrast to the pandemic school.

Some questions of the 2020/2021 teacher questionnaire specifically concern the activities conducted in distance learning: out of 59 teachers, 56% of respondents report that their students were able to work from home on Minecraft activities, compared to 44% of teachers for whom distance activities for their students were not possible. Why? What were the obstacles to the use of Minecraft at a distance? Firstly, connectivity (36.2%), then inadequate devices (32.2%) or completely absent (22.6%).

At the end of the school year (June 2022), a follow-up survey of the just-concluded experience was administered to the 237 teachers involved in the three-year experimentation, to which 150 subjects responded. Figure 1 shows the percentage distribution of teachers who continued to use Minecraft in their classroom teaching: over 41% of the subjects continued to use Minecraft as an immersive teaching environment, almost 29% used it for a period but not at the time of completing the questionnaire, and 30% of respondents ended the experience without further using Minecraft in school with their students.

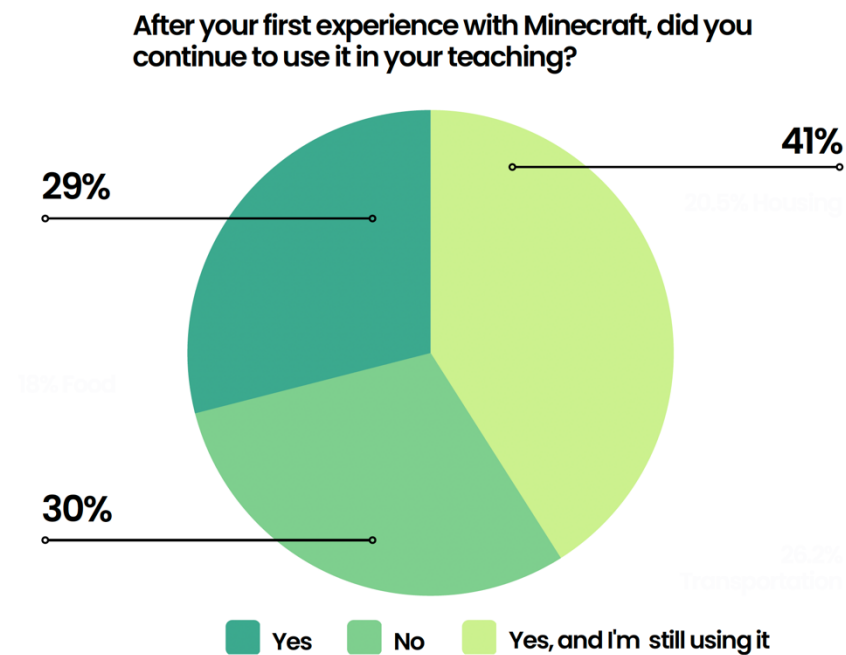


Figure 1. Percentage distribution of teachers who continued to use Minecraft in their teaching (database: 150 teachers out of 237).

The following graph delves into the characteristics of immersive teaching implemented. Immersive teaching has been practiced "at least once" for almost 55% of the subjects, "three to five times" for 24%, and for more than five activities for 21% of the respondents (see Figure 2).

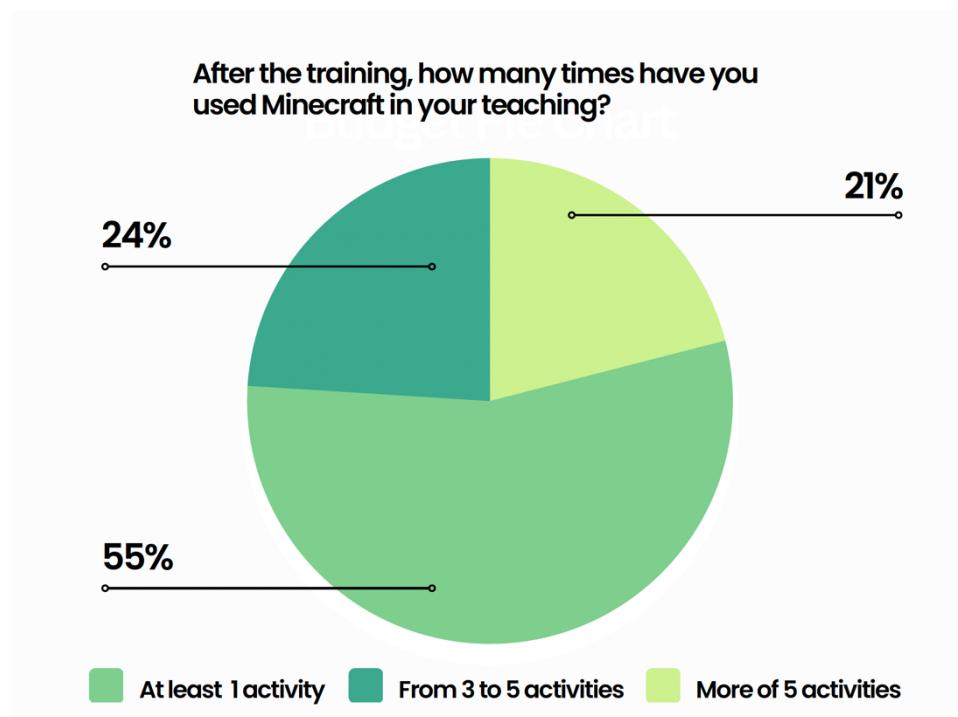


Fig. 2. Percentage distribution of teachers based on the number of times they used Minecraft in their teaching after the initial experimentation.

Minecraft has accompanied teachers' practice even in remote teaching for 63% of teachers, while 37% have not experimented with Minecraft remotely. This portion of teachers who have engaged in forced immersive distance teaching has highlighted some elements of using Minecraft in remote teaching as added value: the development of disciplinary skills (2.5% of respondents), socialization (5% of teachers), and above all motivation and engagement (for 43.6% of teachers), development of cross-cutting skills (23%) and autonomy of the students (20.5%); 5% of responding teachers do not find any added value. The data are summarized in Figure 3.

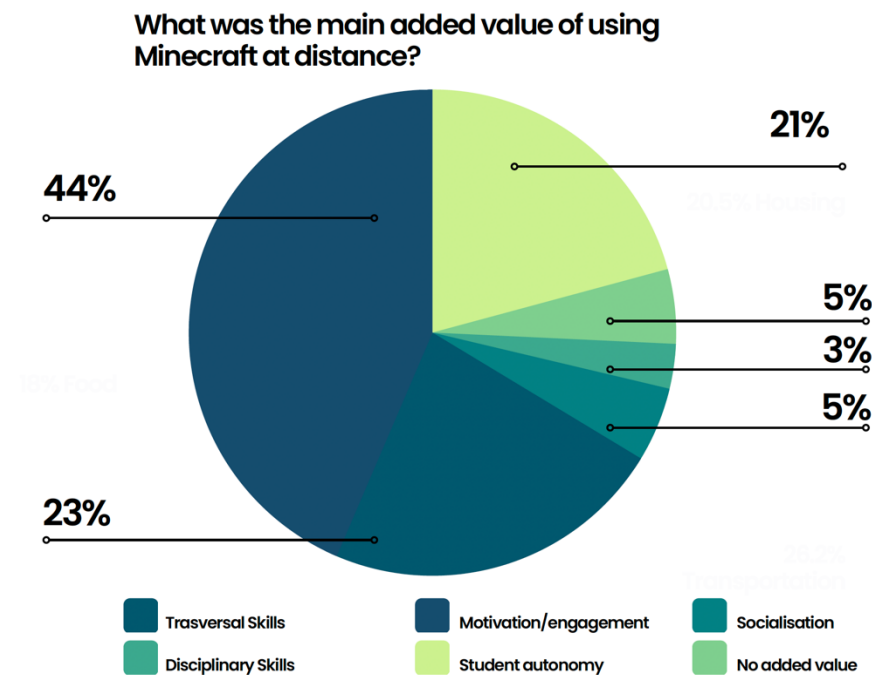


Fig. 3. Percentage distribution of teachers based on the added value observed in the use of Minecraft for distance learning.

In April 2020, in the midst of lockdown, semi-structured interviews were conducted with teachers who were carrying out activities in remote teaching with Minecraft, always within the MineClass project.

First and foremost, the importance of working together, albeit remotely, for the construction of a digital artifact emerges: collaboration among students is a skill that must be exercised from the earliest years of school, and the opportunity to experience it during the pandemic through a Minecraft game world was welcomed by teachers as a positive factor. A primary school teacher (Comprehensive Institute in northern Italy), who involved a first-grade class, responded:

*First and foremost, the importance of working together, albeit remotely, for the construction of a digital artifact emerges: collaboration among students is a skill that must be exercised from the earliest years of school, and the opportunity to experience it during the pandemic through a Minecraft game world was welcomed by teachers as a positive factor.*

A primary school teacher (Comprehensive Institute in northern Italy), who involved a first-grade class, responded:

*If there was a critical aspect, it was their collaboration: they are small, the collaborative competence has just started. For example, the girl who chooses a cube of a color that the boy doesn't like. But I wanted them to try to work together.*

We report in Figure 4, as an example, an exchange in chat between two girls in the teacher's class:

GIULIA: OK INTENT LET'S START WITH THE HOUSE, WHAT ABOUT MAKING THE SECOND FLOOR THE SMALL TERRACE AND THE THIRD FLOOR A BIG WIDE ONE?

WHAT FLOOR DO YOU WANT IN THE HOUSE: DO YOU WANT COLORED CARPETS? WHAT COLOR?  
 WHAT FLOOR DO YOU WANT ON THE TERRACE? SLABS OF WOOD? OF BETULE?  
 WHITE DOORS? WHAT COLOR WINDOW GLASS DO YOU WANT?  
 DILETTA: HELLO GIULIA, IT'S OKAY FOR THE COLORED CARPETS AND WHITE DOORS, NOW I WILL  
 INSERT THE BLOCKS. YOU BUILD. CAN YOU CHANGE THE COLOR PLEASE?  
 I HAVE A HARD TIME READING. OK THE TWO TERRACES AND MAKE A BIG CARPET, LET'S PUT MANY  
 COLORS

Figure 4. Communication between two girls in a first-grade class at a Comprehensive Institute in northern Italy while working on a collaborative building project in Minecraft.

A second recurring aspect in the interviews concerns how distance has influenced students' methods of documenting activities. A high school teacher explains:

*I opened a Padlet in which individual student groups can put the material they are viewing for the design of their building in Minecraft. This mode was necessary to share the projects of individual buildings and the phases of work between groups, thus creating the advantage of documenting each phase of the work.*

From these words, it can be seen how the remote mode, combined with the need to coordinate in carrying out a shared construction, has pushed - almost forced - students to pay more attention to the quality of documentation.

## Conclusions

Despite some obvious difficulties in conducting distance learning laboratory activities during the pandemic months (Gamage et al., 2020), the experience conducted and presented in this contribution confirms the benefits found in previous research on the use of remote laboratories (Fadda & Vivanet, 2021), the implementation of online game-based learning paths (Wardoyo et al., 2020; Yang et al., 2022), and immersive distance learning conducted with Minecraft (Rader et al., 2021; Sena & Jordão, 2021). The greatest benefits can be traced to students' ability to socialize, work in groups (even at a distance) and independently, showing greater motivation and engagement compared to more traditional educational and learning activities. A good portion of the teachers included in the study continued to take advantage of the potential of Minecraft-based education even during school closures, demonstrating the validity of the experimentation conducted in the years prior to the pandemic.

The level of use of this methodology compared to the overall educational offer of teachers is also significant. The results related to the development of socialization skills, teamwork, autonomy and distance problem solving are further experienced and deepened. With the increasing diffusion of laboratory education in secondary schools, product and process evaluation that supports competency-based learning processes has entered disciplinary learning spaces, and laboratory teaching activities focused on technological artifacts such as Mineclass seem to have supported the development of critical thinking among students, meta-reflection and co-construction of learning processes. Some 'side effects' of distance learning have widely favoured the use of online documentation (in these examples with a padlet) to follow step-by-step phases of group activities, and constitute some feedback on the development of students' metacognition and reflection on cognitive processes, implemented within the disciplinary aspects that make the school of doing increasingly practicable also in high school. The same national surveys on distance laboratory education underline this passage, for which distance laboratory work goes beyond the "synchronous hour" and spills over into afternoon group activities in secondary school (Indire, 2022). The results also show the emergence of a widespread mode of laboratory teaching, where the classic laboratory is displaced and exits the classroom: it opens up to a time of school at home for laboratory work and collaborative activities, and peer-to-peer laboratory work can also take place in the afternoon, be managed in small groups and deepen activities in a cross-cutting way. Without claiming to be exhaustive, the reflection is on how these aspects can constitute further enabling elements for deepening immersive teaching in high school as a laboratory mode, even in the context of a new normality school.

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