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Minecraft: A means for the teaching and the disclosure of physics

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Summary. — Today, given the actual coronavirus emergency and the increasing use of remote learning, employing new technologies is required to develop alternative and interesting ways to teach physics. Education specialists believe that the use of video games is very useful to educate single or groups of students of different school levels. In this frame, we assembled a "Physics Park" in which students can learn the theory of experiments and carry them out, even cooperating with each other, by means of Minecraft, a sandbox video game. Here, we present "Galilei's Acceleration Experiment" with which Galileo Galilei proved the law of falling bodies by using an inclined plane with small bells. Our aim is to develop a teaching method that not only allows and improves the learning of physics, but also makes it more interesting and accessible.

1. – Introduction

Physics is one of the STEM (Science, Technology, Engineering and Mathematics) topics that students —and, generally speaking, people— find most complex and difficult to learn [1]. In fact, even if physics is involved in facts and phenomena that occur around us all the time, not a lot of people have a good understanding of it, and many believe that it is not relevant to their daily life, which is why they have no incentive to do well in it. For this motivation, and also, probably, for the lack of passion and for the "fear" of not having the right basis or not being able to face the difficulties that will be encountered during the course of studies, a very small number of students, after completing their high school studies, enroll in degree courses in physics [1].

In addition to all these considerations, in 2020, in response to the COVID-19 pandemic, schools and universities in Italy and across the world have closed to ensure the safety of teachers, staff and students, forcing them to use remote learning techniques and having a very important impact on students' education [2, 3]. Basically, distance learning is a mode of teaching and learning that was already available before the coronavirus emergency, but often used in a limited and asynchronous way, allowing only the most self-motivated and/or highly self-disciplined students to complete courses [3, 4].

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In this frame, education specialists are always seeking to elaborate new methods to make learning of physics more interesting and effective, also to get closer to the new 21st century education standards [5, 6]. For example, gamification and game-based learning (GBL) are teaching methods in continuous development and diffusion that balance educational materials with the basic aspects of playing a game (*i.e.*, strategies, rules, and social aspects). In the past years, GBL has been endorsed as one of most effective method to increase students' interest and learning efficacy on education and STEM subjects [6-11], also allowing an active collaborative mode [12, 13]. In particular, the use of video games in order to increase the learning process and the curiosity of students in STEM subjects, has been widely tested with positive results [6, 14, 15].

One of the most used video games with a great effect on students is "Minecraft", which boosts creating, problem-solving, multitasking, social/collaborating and research skills [6, 16-18]. Minecraft is a sandbox video game that consists of a virtual environment with simulated law of physics in which 3D blocks can be mined or crafted [19]. Minecraft can currently be used on a variety of platforms and operating systems allowing for gaming activities and synchronous cooperation between online players. These features make its use interesting for educational purposes, and, in 2016, an *ad hoc* version of the game known as "Minecraft: Education Edition" (MEE) was created [17, 20, 21]. MEE is currently considered to be a very useful tool for teaching individuals or groups of students of different school levels by education specialists, even to achieve new academic breakthroughs [8]. In fact, the use of this video game is supported by a rich bibliography that gives evidence of its importance in several learning environments (such as in primary school [17] or higher institutes and universities [22]), for different topics [15, 23], and in teaching children with disorders (*e.g.*, socialization problems), or, more generally, to students of all levels of learning and/or ability [9].

Here, by means of MEE, we propose the creation of a park dedicated to physics in which we introduce, explain and reproduce experiments and phenomena to students of different school levels.

2. – Physics park

The "Physics Park" was created in MEE not only with the aim of encouraging learning, but also to support collaboration and exchange of opinions between students and users.

Once inside the park, at the main entrance, we will be invited by Dr. Benvenstain to head to the information center or take a walk along the "Physics Avenue" that connects various areas of the park. The information center with its non-player characters (NPCs) allows us to receive additional information about the park and other activities by redirecting to the official URL of our department, and, in addition, to immediately move to different areas of the park, such as the panoramic viewpoint. From here, it is possible to take photos creating albums (portfolio) and view several areas of the park, such as the main entrance and a "Relax area" in which users can exchange information and chat/communicate with others. For each subject matter concerning physics inside the park, the use of both a classroom for learning the theory and an area dedicated to the practical experiment is foreseen.

Here, we present Galileo's experiment on acceleration which was also the first topic dealt with within the park.

3. – Galilei's acceleration experiment

Using an inclined plane with small bells, Galileo Galilei (1564–1642) provided an experimental demonstration of the Galilean law of falling bodies [24]. The experiment consists in releasing a small ball from the top end of the plane that strikes one of the small bells placed along the inclined plane at increasing distances, arranged in the sequence of odd numbers. This attempt allowed not only to measure the increase in the distances traveled by a body in natural fall in successive and equal time intervals starting from the resting position, but also provides an acoustic perception of the constant acceleration of the ball during its fall, thanks to the ringing of the bells. Galilei concluded that if an object is released from rest and gains speed at a steady rate (as it would in free-fall or when rolling down an inclined plane), then the total distance d traveled by the object is proportional to the square time required for that journey: $d \propto t^2$. For a ball rolling down an inclined plane, this acceleration relates to the gravitational acceleration g and we have $d = \frac{gh}{2l}t^2$, where h and l are the height and the length of the plane, respectively.

3˙1. *The classroom.* – As showed in fig. 1(a), in the virtual classroom, it is possible to listen to the lesson of an NPC teacher and/or follow the text on the blackboard, even acquiring more information by means of one or several URLs on the subject matter. In addition, students can read the tome placed on the bookstands and possibly take one from the crates at the entrance to the class. The book can also be downloaded to their PC for future reading or it is possible to listen to its content through immersive reading which can make a fundamental contribution in the case of students with particular difficulties.

3˙2. *The experiment.* – By emulating the small balls with a student on a "minecart", we have created two inclined planes (fig. 1(b)) in which it is possible to place bells to verify what was previously learned in the classroom. At the highest point, it is possible to obtain i) information from the NPC, ii) additional bells and minecarts to perform the experiment over and over again, and iii) choose to test one of the inclined path. In particular, one inclined plane allows to reproduce the experiment carried out by Galileo, while in the other path, a rail has been inserted and, when activated, accelerates the minecart just before the descent. Once the bells have been positioned, as the minecart passes, it will be possible to hear them and perceive if they have been spaced correctly, also through the use of a stopwatch. The experiment thus realized makes not only the direct verification of the physical phenomenon or the learning-by-doing teaching method possible, but also the collaboration and the constructive discussion between users, for example, in the positioning of the bells, in the improvement of the approach in the experiment and/or even the realization of a portfolio.

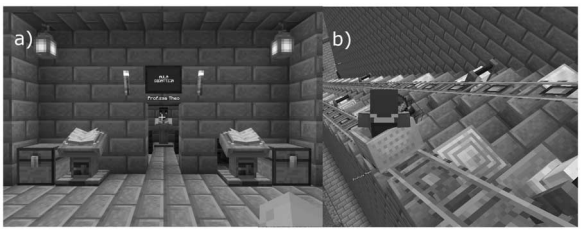

Fig. 1. – (a) The classroom of the park dedicated to Galilei's experiment. (b) The experiment realized by means of a "minecart", bells and inclined paths.

4. – Conclusions

Minecraft Education Edition is a powerful distance teaching and learning tool, currently fundamental given the situation of the coronavirus pandemic, which allows the creation of theoretical and experimental teaching environments on STEM subjects and, in particular, physics, making it more interesting and accessible, and encouraging synchronous collaboration. This approach has been enthusiastically welcomed by the teachers of various local schools who are also trying to start projects in this regard, having found particular interest from students in starting this learning activity.

In this context we have proposed the creation of a park dedicated to physics that can contain various activities within it.

The first topic addressed is the theoretical study of uniformly accelerated motion in falling bodies, an activity supported by a classroom in which it is possible to find a NPC teacher, a blackboard and readable and downloadable books for later reading. Experimentally, the theory is verified through Galileo's inclined plane experiment.

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