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The History of Science, Technology and Interdisciplinarity: An Engaging and Innovative Teaching Proposal

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Abstract

There are many studies that value the use of the history of science for its numerous educational effects and its use is suggested in the school programs of various countries of the world. Through the study of history and the nature of science, students have the opportunity to appreciate not only the final results but also the processes that led to the formulation of scientific ideas, understanding how often the construction of a theory is the result of a long and tortuous process that over the past times clashed with fears, superstition, astrology and religion. In this teaching proposal we want to retrace what led Galileo to abandon a cosmological vision that has lasted for 2000 years and deal with his discoveries, achieved using a simple telescope, in which he believed so much to challenge authorities and prejudices, pursuing what was the goal of his whole life: demonstrating and spreading the heliocentric theory.

It is an important moment in the history of the thought of humanity: understanding the fundamentals of scientific and intellectual change is an essential exercise in order to transfer to our students what science is, when it was born and what it was born from. But how to teach this to high school students? Many researches have shown how the teaching that involves more sensory aspects can promote motivation and learning, while technology can be a fabulous tool to engage our students. What is proposed here is the use of the ThingLink platform as a tool that allows access to visual, interactive images, sounds and videos, even in a 360° degree's view. The smartphone becomes a tool to enjoy and build engaging paths even in the form of immersive virtual reality. The path will show the importance of Galileo's astronomical discoveries and their consequences in physics, philosophy, religion and how there is a trace of them in the artworks of museums, churches and palaces in Florence, Madrid, Monaco, Rome, as a demonstration of how art, at that time, received scientific innovations and was an important medium in spreading new ideas. In conclusion, the history of science can be a means to help overcome the traditional separation between science and humanities and technology a powerful tool to stimulate the interest and creativity of our students.

Keywords: *History of Science, Galileo, Virtual Reality, Motivation.*

1. Introduction

A series of studies conducted in recent years have been signaling an alarming decline in the interest of young people in the subjects of science and mathematics. In April 2007, the so-called Rocard Report was published, as a result of the work of a committee of experts on science and research of the European Parliament presided by Michel Rocard.

This report points out how the growing disinterest of young people towards science is a capital danger for the future of Europe and indicates that the origin of this issue can be traced back, among other things, to the way science is taught. It recommends teaching methods not tied to memory learning or abstract concepts and promotes research-centered approaches on how the process of science take place, even historically.

There are many studies that value the use of the history of science for its numerous educational effects and its use is suggested in the school programs of various countries of the world, though it is still not clear what needs to be taught and how to do it.

There have been many methodological proposals in the past: reading of original texts, reconstruction of historical experiments, analysis of disputes, dramatizations, comic book creations, etc.

What we propose here is a multidisciplinary and interactive course, inspired and built starting from one of the recommendations of the EU COUNCIL of May 22, 2018 relating to key competences for lifelong learning, suggesting "*to promote the acquisition of skills in science, technology, engineering and mathematics (STEM), taking into account the links with the arts, creativity and innovation*".

The main objective of the proposal is to convey to the students how the birth and genesis of the concept of today's science was a long and tortuous path; the theme treated as a supporting

background is "The astronomical discoveries of Galileo" for their numerous consequences in astronomy, physic, philosophy and religion.
This work involves the use of multiple teaching strategies: reading and discussing the original texts, construction of scientific instruments of interest and the use of art as a starting point for reflection and as a demonstration of how art was an important medium in spreading new ideas.
One of the inspiring ideas is to attract students by means of a new 3D technology with immersive Virtual Reality (VR) as a powerful way to involve them.
The course has been proposed to a class of students aged 15, during the physics' course, who responded with interest and enthusiasm.

2. Materials and Methods

The ThingLink platform has been chosen as the supporting backbone of the teaching proposal.
ThingLink is an innovative tool and an important support for learning, which allows to visually and interactively connect texts, images and videos and which allows to build courses and lessons that can also be enjoyed in a flipped classroom model whose potential is highlighted in the literature [4] [5]. The peculiarity of this platform consists in being able to use 360° images that can be viewed on a laptop or in VR mode with a smartphone, by using a simple cardboard. Using a VR platform, the students benefit from rich opportunities in experiential learning, which are inclusive of all learning styles, needs and abilities.
In the present case, a ThingLink project in VR mode has been created, bringing together multimedia content, significant places and works of art (captured with a 360° camera) related to the theme.

3. Educational Path

The VR educational path begins in the wonderful Palazzo Spada in Rome and guides the student in search of a symbolic painting of the scientific debate of the seventeenth century, between the heliocentric and the geocentric theory: "*The Astronomers*" by Niccoló Tornioli. The analysis of the painting introduces fundamental themes to reconstruct the millennial path that led to abandon the geocentric system. The following step focuses on Galileo's astronomical discoveries and their interpretation, where the students begin to see Galileo as the modern scientist who observes meticulously with an agile mind, curious and completely free from prejudice, eager to reach a single conclusion: the truth. The VR artifacts shows some pictorial and artistic testimonies related to these discoveries in Venice, Florence, Madrid and Monaco.
Galileo's investigative tool was the telescope, a tool that changed the history of astronomy and contributed to cancel 2000 years of Aristotelian philosophy and marked the unequivocal evidence of the need to build a new physics. Students can move virtually in the Galileo room of the History of Science museum in Florence and observe, among other things, the remaining Galilean telescopes. Furthermore, following S. Papert, the father of the constructionism, who suggested that learning is more efficient when it is part of an activity such as building a meaningful artifact, the student were engaged in a laboratory working at the construction of the telescope and helioscope as Galileo did it.
Also, the laboratory was focused in reading parts of Galileo's "Sidereus Nuncius" (book in which Galileo talks about his telescope and his astronomic discoveries), some of them related to the construction of the telescope itself. With scissors, lenses, glue and cardboard, a 10x magnification telescope was built, such as the one that was presented for the first time by Galileo to the Doge of Venice. Today we know the formula of telescope magnification, but how did Galileo determine it? Reading the Sidereus Nuncius students can appreciate the simple practical genius of the eminent scientist.
Using the Galilean telescope is then possible to truly understand the observational difficulties of the past: small field of view, chromatic aberration, difficulty of pointing, how difficult it must have been for Galileo to reconstruct the face of the Moon. Nothing to do with the use of a simple common telescope that can be used by everyone today.
But beyond the enormous observational difficulties, with patience and precision, Galileo gave meaning to small details putting all the pieces together and turning small things into great discoveries. The new image of the surface of the Moon wipes out 2000 years of Aristotelian cosmology: the division between sub lunar and celestial world does not exist, the Moon is of the same matter as the Earth, and the sky is populated by countless objects not visible to the naked eye. All these discoveries definitely highlight how the universe is fundamentally unknown, along with undermining the foundation of astrology.

At that time astronomers were also and above astrologers: in the homocentric vision of the universe, everything was functional to man and everyone, regardless of status and wealth, resorted to astrology. How was then possible to justify horoscopes if there were objects never seen before in the sky?
Moreover, Galileo's ingenious method for observing sunspots and the witty geometric interpretation of their movement allows him, using only reasoning and observation, to dismantle the imaginative and preconceived interpretations originating from the Aristotelian doctrine.
Finally, the discovery of Jupiter's satellites asserts the fundamental truth that not everything revolves around the Earth and a celestial object can safely move in space without losing its satellites: so why Earth can't behave the same way? One of the fundamental objections to the Earth movement was that the Moon could not have maintained its orbit, in case the Earth was moving. So how is that possible? This and other unresolved questions highlight the importance of rebuilding a new physics: no longer an Aristotelian physics based on the centrality of the Earth, but a new physics that can account for terrestrial phenomena assuming earth movement.
The 360° VR tour ends with a visit to the "Il Gioiello", the house now owned by the University of Florence in which Galileo, by then blind, spent his last years in confinement. In this place he received the visit of the poet John Milton (of which various paintings report the event) who later published the "Areopagitica" - his defense of free speech - where he mentions his journey to Italy and says "*There it was that I found and visited the famous Galileo grown old, a prisoner to the Inquisition, for thinking in Astronomy otherwise then the Franciscan and Dominican licensers thought*".
Here Galileo died January 8th, 1642.

4. Results and Discussion

The students have followed the course with interest and enthusiasm. Beyond the content presented, there were many food for thought originated by the course itself: science and pseudoscience, science and technology, the role of scientific academies in the past and many more topics.
As a final remark, after knowing and appreciating this part of Galileo's work, the students were offered a reading of Galileo's abjuration. In those words: "*I abjure with a sincere heart and unfeigned faith, I curse and detest the said errors and heresies, and generally all and every error and sect contrary to the Holy Catholic Church*" the students, without any explanation from the teacher, have discovered and recognized how much the genesis of science in the past (and perhaps today) had to struggle with prejudices, personal interests and abuses.
The final test has proved a good understanding of the concepts exposed during the project.
Furthermore, the student's emotions were collected via an anonymous questionnaire and as it can be seen in Figure 1 there is no sign of boredom, tension, sadness or anxiety but only enthusiasm, happiness, fun, satisfaction and surprise. It is reported that positive emotions can successfully influence learning behavior [6].

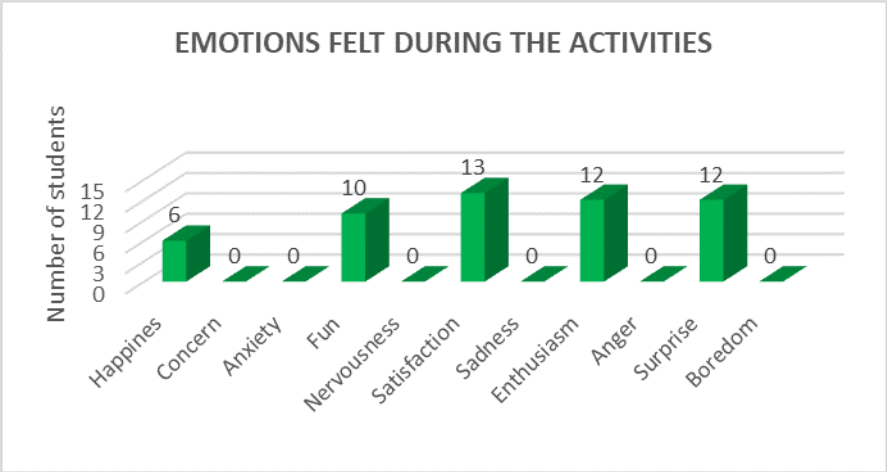

Figure 1 – Survey's result on the student's emotions

5. Conclusions

The history of science can be a good means to stimulate the interest of our students and may help to overcome the traditional separation between science and humanities. Adding the technology as a

powerful tool for involvement, all these elements can help to build an interdisciplinary STEAM curriculum [7] and support the students to develop competencies and skills for 21st century [8].
The survey's outcome shows that the students are ready to learn and participate with an active mindset: the key to the success is to find different or complementary approaches to traditional methods, believing that the proposed work is one of them.

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