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Research Article

Bridging the gap: From the laboratory science education of the 19th century in Greece to STEM education

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ABSTRACT

The objectives of the present study are to investigate both the history of the collection of scientific instruments from the Maraslean Teaching Center (MTC) and the potential for the collection's use in STEM education programs. Although MTC went by a number of different names during its long history, its institutional goal remained the same: training the Greek state's primary school teachers-to-be. To so do, it was necessary to assemble a collection of scientific instruments. The first objective of the paper is to present in detail the gradual enlargement of the collection from the last quarter of the 19th century through to the 1930s, along with the way the instruments were used in science lessons and the central role MTC played in relation to other regional teaching schools in Greece in terms of the distribution, administration, repair and maintenance of the equipment. The second objective is to investigate the role the historical scientific instruments can play not only in the history of science, but also in contemporary science teaching. The findings reveal that the history of laboratory physics education in MTC along with the corresponding collection of the historical scientific instruments can be a fertile ground for implementing STEM education programs. Finally, the findings imply the broader integration of STEM education and history of science in order to promote cultural and procedural aspects of science in student teachers and beyond. Such integration gives rise to broader research on introducing STEM education to cultural embedded environments, such as museums and historically important schools and laboratories, such as MTC.

Keywords: Maraslean Teaching Center, STEM, scientific instruments, science education

INTRODUCTION–HISTORICAL BACKGROUND

When the modern Greek state was founded in 1830, it lacked all the basic infrastructure of a modern state, including schools. There was an imperative need to set up primary schools, and thus also to arrange for teachers to be trained to staff these schools. This was the context in which the Royal Teaching School (RTS) was set up as an institution, where men and women could study with a view to teaching in primary education.

The teaching school, which was the first professional school in Greece, operated for one year in Nafplio before moving to Athens, when the latter became the new capital of the state. Natural sciences occupied a secondary place in the curriculum, and there is no mention of the teaching school being equipped with scientific instruments or a science laboratory. RTS was abolished by law in 1864 for reasons that fall beyond the scope of this article.

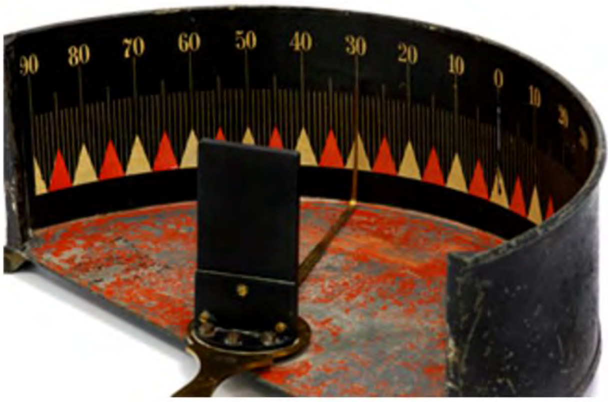

Figure 1. Muller device for study of reflection (Manufacturer Leppin & Masche, manufactured around 1880) (Photo by P. Lazos)

In this context, the present study focuses on the investigation of the history of laboratory science education and particularly the history of the collection of scientific instruments of the Marasleion Teaching School (MTS). Moreover, the study focuses on investigating the possibility of the collection being an appropriate context for STEM education programs, including cultural aspects of science and science education. The importance of the study lies in the fact that it is in the direction of the preservation and promotion of the cultural heritage in combination with the modern teachers' science education. To achieve the objectives of the study, traditional literature review was followed, both regarding the collection of the historical scientific instruments and their educational use in STEM education as well.

FROM THE ROYAL TEACHING SCHOOL TO THE MARASLEAN TEACHING CENTER

The Greek state remained without a teaching school for twelve years, until 1876, when MTS in Athens was founded. Science was clearly upgraded in the new program in which it now accounted for 16% of the total teaching hours, a science-focus, which had no precedent and would not be equaled for another four decades.

In addition, starting in 1879, MTS began to acquire experimental instruments for physics; a little later, in 1882, a laboratory technician was appointed to teach the science courses (Tampakis, 2009), which is indicative of the extent of seriousness with which the laboratory teaching of science was treated. Instrument purchases continued throughout the 19th century, so that in 1899 the inventory of MTS in Athens laboratory included more than 230 physics instruments and devices, 70 chemistry instruments and utensils, and a sizeable number of chemical reagents. The instruments that have come down to us from this period and bare a stamp are stamped with the mark of the French manufacturer E. Ducretet (Ducretet, 1893). We believe that most of the instruments purchased during this period came from France and were quite possibly supplied also by Ducretet, given that numerous Greek schools were equipped with instruments made by Ducretet at this time, including the 1st Middle High School of Athens, the Middle High School of Syros (Makryonitis, 2018), and the Middle High School of Amfissa (Andrikaki, 2016). We are therefore of the opinion that this company had been selected centrally by the Hellenic Ministry of Education. In any case, French manufacturers of scientific instruments offered both excellent quality and a wide range of products in the latter half of the 19th century (Brenni, 2012). Nonetheless, some of the surviving instruments are of German origin. These are four physics instruments manufactured by Leppin & Masche, a company founded in 1869 (**Figure 1**) and two instruments by Ernst Schotte, founded in 1855.

Apart from physics instruments, the equipment acquired in the late 19th century also includes certain contemporary technological innovations, which highlight the effort of Greek society to keep up with the technological and scientific developments of the 'advanced' West. For example, a Davy-type safety lamp for miners, an Edison phonograph made by Ducretet (**Figure 2** and **Figure 3**) purchased in 1890–not long after its invention in 1877, a stereoscope, two pairs of telephones made from Bell and Siemens, an electric telegraph by Morse, and a zoetrope.

Figure 2. MTC collection phonograph (Photo by P. Lazos)

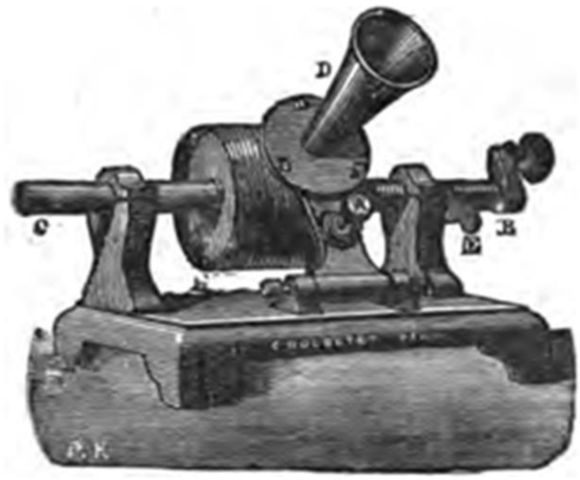

Figure 3. Phonograph of collection as it is depicted in a Ducretet catalogue (Ducretet, 1893)

The year 1880 saw two more schools founded–one in Tripoli (the Peloponnesian Teaching School) and another in Corfu (the Ionian Islands Teaching School) (Teaching Centers, 1880)–while the annexation of Thessaly to the Greek state was followed by the establishment of a school in Larissa (Thessaly Teaching School) in 1882. These regional teaching schools were gradually shut down, and between 1907 and 1913 the Athens Teaching School was the only one in operation in the country.

In 1905, the Athens Teaching School was moved to the beautiful neoclassical building, which still houses its collection of instruments today. The cost of constructing the building, of furnishing it and purchasing new equipment for its laboratories was borne by the national benefactor Grigorios Maraslis (1831-1907), a wealthy merchant from Odessa, Ukraine, who had donated significant sums for construction of other Greek educational institutions. A few years later, in 1910, the Athens Teaching School was renamed MTS in his honor.

Between 1922 and 1923, the department of physics and mathematics at the University of Athens acquired numerous scientific instruments and a wealth of other scientific equipment from Germany as part of that country's reparations for the First World War (Vlachakis & Lazos, 2022). We owe both the idea and its completion to the physics professor, Georgios Athanasiadis. Some of these instruments were aimed at schools. MTS has two Hartmann & Braun (Frankfurt) instruments, which were probably also delivered by Germany by way of reparations for the World War I (**Figure 4**). Their delivery is probably linked to the fact that Athanasiadis had been a professor at the Maraslean Teaching Center (MTC) in 1899 for a short time.

THE MARASLEAN TEACHING CENTER

In 1933, the teaching schools phased out and the task of training teachers was undertaken by the pedagogical academies. MTS was thus succeeded in the same building by MTC. The instruments came from all the European physics instruments factories but most of them are now obsolete. Some have been repaired

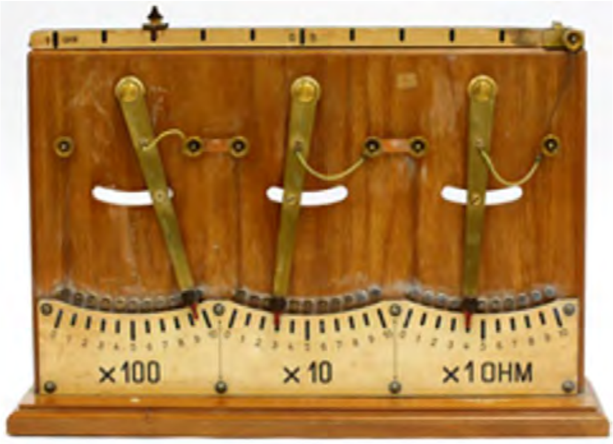

Figure 4. Variable resistor (manufacturer: Hartmann & Braun) (Photo by P. Lazos)

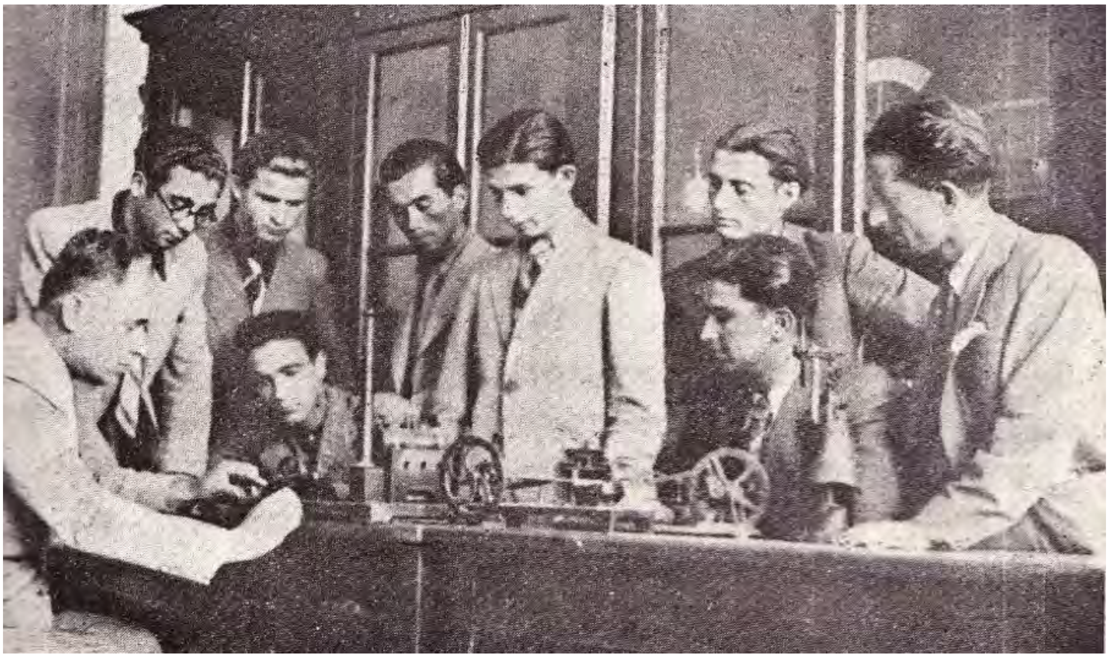

Figure 5. A group of students studying a model of a steam engine with their teacher in special classroom used for teaching experimental physics (Palaeologos, 1939)

and are used by students in the laboratory, but they are not considered the most appropriate instruments for the task (Palaeologos, 1939).

Dimitrios Gizelis, a professor of physics at MTC in the 1930s, puts forward the highly pragmatic view that the academy's instruments should be simple and low cost, since this was the sort of instruments the trainees would most likely encounter in the schools they would later teach in.

In the 1937-1938 academic year, the Greek state provided the pedagogical academy with 300,000 drachmas to upgrade its science laboratories. A fraction of the amount was used to buy 62 physics instruments and devices (Marasleion Laboratory Inventory, 1937) of which fewer than 20 have survived. The equipment was manufactured by PHYWE, and the purchase was made through the company "D. Dimitrakos & Sons", the German company's representatives in Greece.

LABORATORY SCIENCE EDUCATION AT THE MARASLEAN TEACHING CENTER

There are few available resources relating to how laboratory work was conducted at MTC. However, Gizelis' detailed description, which relates to the late 1930s, probably provides a picture that is representative of the situation more generally (Palaeologos, 1939). Thus, according to Gizelis report on the function of MTC, experimental physics was taught two hours a week in a special classroom (**Figure 5**).

Particularly, depending on the type of exercise, the forty or so students in each class would either work all together or be divided into two different sections to form four groups of five. The first option was preferred for tasks, which required a lot of equipment, such as optics exercises involving lenses and mirrors, or magnetism. Where this was not possible, the four groups of five option were employed. Even then, the laboratory was not equipped with multiple instances of the same instruments and devices. The solution was therefore to use four different experimental set-ups and to have the groups take turns working with each. The use of hydrostatic scales, pycnometers, a Mohr's balance and a vessel for determining the density of a liquid are mentioned as examples. Similar solutions were used when studying the expansion of bodies. The final comparison of the results each group arrived at fostered a healthy competition as well as focused the students' attention on the task at hand.

A similar practice was employed in the chemistry laboratory. The room could accommodate thirty students on three laboratory benches equipped with thirty Bunsen burners. The students' preparations had necessarily to be done in small groups using small quantities. This made it quite challenging to study all the properties of the substances produced. Where necessary, special devices were used, which were capable of producing large quantities of the substances being studied; the properties of the substances produced would then be demonstrated to the whole class.

Very little laboratory work was done in Biology, since, in the academic year Gizelis refers to in his report–probably that of 1938-1939–extra time had to be allotted for experimental physics. This was because the second year students had not been taught the experimental physics included in the first year syllabus, and the material had to be covered. Observations of plant cells were made from ready-made preparations, and students practiced using the microscope and preparing cross sections of samples.

THE MARASLEAN TEACHING CENTER'S ROLE IN DISSEMINATING SCIENTIFIC INSTRUMENTS IN GREEK EDUCATION

MTC was the oldest teaching school. Because it was located in the Greek capital, it had become a hub for the provision of scientific instruments to the other teaching schools. Thus, for example, on 2 March 1900 the Ministry of Education delivered 29 instruments to the director of MTC professor Timoleon Argyropoulos, so he could dispatch them to the Thessaly Teaching School (Tampakis, 2009).

When the situation required, the instruments could travel in the opposite direction, from the provinces to MTC. As Gizelis mentions, the equipment of many teaching schools, which phased out in the 1900s, were brought to MTC (Palaeologos, 1939). It also seems that some instruments from high schools ended up in MTC collection on a permanent basis, perhaps when they were no longer useful due to their age but retained their value as museum pieces. The "small electric machine of the old system" from the Corfu Gymnasium (established in 1866), which was transferred to MTC in 1898, is one such example.

MTC also had a well-equipped workshop for repairing instruments; this was referred to as a "machine shop workshop" in 1899. In addition, MTC was said to have a "physics instrument laboratory" in 1937 (Palaeologos, 1939). Provincial teaching schools sent apparatus to MTC that needed repair. One such case is found in the inventory from 1899 in which 22 apparatus from the Ionian Teaching School are listed and described as "incomplete and in need of repair". Given that Greece did not have a state facility for the repair and manufacture of scientific instruments for education until 1948, MTC had to maintain a basic workshop, where necessary repairs could be carried out and which served the other teaching schools as far as possible. The Workshop for the Repair and Manufacture of Physics Instruments, the forerunner of the Factory of the Ministry of Education's Center for Supervisory Teaching Aids, was founded in 1948 (Kampouris, 2006).

Panagiotis Kondylis taught physics at MTC in the 1890s, until he was succeeded by Georgios Athanasiadis in 1899. In 1898, Kondylis became "inspector of physics instruments [...] appointed by the Ministry of Education by dint of document number 4441/3373 of 28 March 1898" (General State Archives: Cyclades Collection, n. d.). In the course of his duties, he travelled to Syros on 23 April 1898 to inspect the instruments at Syros High School. He drew up an inventory of the equipment on the same day with the help of the school's director and mathematics teacher. According to entries in the inventory, Kondylis took eleven of the school's instruments back with him to Athens to be repaired and returned. A further eight instruments (duplicates or unusable/unrepairable) were handed over to Kondylis to be loaned to other schools (General State Archives: Cyclades Collection, n. d.). The same procedure was repeated at the 1st Athens High School for Boys, where Kondylis took away thirty physics instruments for repair following an order from the Ministry of Education (General State Archives: Athens Collection, 1898). The note also states that some of the instruments were returned repaired, others were returned still out of order, and some were not returned at all.

It is not clear whether Kondylis' accepting receipt of the apparatus in the previous cases was directly linked to the activities of MTC, or whether it was an entirely independent task delegated to the "inspector of physics instruments". However, even if the latter were the case, it is reasonable to assume that Kondylis was appointed to the post in the light of the knowledge and experience he had acquired during his many years of service at MTC.

Finally, it should be noted that the capabilities of MTC's physics instrumentation workshop were not limited to repairs, and included the technical knowledge and skills required to construct apparatus. The physics and chemistry apparatus inventory for 1930 mentions a device for measuring linear expansion, which had been constructed by the workshop (Tampakis, 2009).

END OF MARASLEAN TEACHING CENTER AS AN INDEPENDENT EDUCATIONAL INSTITUTION–THE CURRENT SITUATION

MTC operated until the late 1980s; the first university pedagogical departments for training primary school teachers were established in 1985. The academy's laboratories were no longer in use and the instruments were neglected. The situation was aggravated by the powerful earthquake of 1999, which caused extensive damage to the building. Despite the dangerous condition of the building, most of the instruments were transferred to safety, thanks to the efforts of a group of PhD students. The building was repaired and handed over safe to the university in the 2009-2010 academic year, and the saved instruments were re-installed in two rooms in the basement of the building.

Half of the approximately one hundred and forty surviving instruments were made up to the 1930s by European manufacturers including E. Ducretet (Paris), Ernst Schotte (Berlin), E. Zimmermann (Leipzig–Berlin), Hartmann & Braun (Frankfurt), Leppin & Masche (Berlin), Paul Gebhardt Sohne (Berlin) and PHYWE (Göttingen). The equipment acquired after World War II were mainly manufactured in the workshop of the Ministry of Education's Center for Supervisory Teaching Aids in Athens.

The following paragraphs analyze the value of preserving historical scientific instruments internationally and looks at their educational use in an environment that is being shaped by contemporary trends in both formal and informal science education.

HISTORICAL SCIENTIFIC INSTRUMENTS & STEM EDUCATION

Awareness of the scholarly value of historical scientific instruments grew during the 20th century and is reflected in initiatives, such as the scientific instrument society and the scientific instrument commission. The study of scientific instruments can provide fundamental insights into the creation and transmission of knowledge (alongside complementary approaches to the history of science, technology, education, commerce, society, and culture), while it also enriches our understanding of scientific method and practice. Such studies may focus on the role of instruments in research and teaching in given societies. These initiatives are singularly important, as they reveal aspects of the nature of science that are particularly significant both for educational praxis and for the cultivation of a scientific culture among the general public (Brenni, 2008).

Moreover, historical scientific instruments have been inspiring the science education community now for more than 30 years. Science researchers and educators have developed ideas and suggestions about how to introduce historical scientific instruments into formal, non-formal and informal science education with the aim of enhancing students' knowledge of the nature of science and of science itself. Filippoupoliti and Koliopoulos (2014) argued that the most effective means of disseminating the history of science is through a science museum, which provides both non-formal education (structured out-of-school museum activities) and informal education (museum experiences offered to the public). In turn, Pantano and Talas (2010) argued that museums of science history can play a central role in improving the learning of physics concepts through their historical perspectives. As a result, several projects based on the history of science have been proposed in recent years in both a school (Heering, 2000; Holland & Matthews, 1999) and science museum context (Bernarduzzi et al., 2012; Holland & Matthews, 1999). The latter were implemented in a variety of ways: putting exhibits on display, i.e., Museo Galileo; using primary and secondary sources and hands-on reconstructions of historical experiments/instruments (Heering, 2000); and staging student competitions relating to science museum exhibits.

There are many ways in which teachers and students could run projects relating to historical scientific instruments. For instance, while examining the design and function of instruments, there are many aspects to consider: How did the instrument work? What is it made of? How was it made? There is an intimate relationship between an instrument's materials and its intended function. For instance, as techniques were developed in the later 18th century, instrument-makers explored the advantages of different metals in an effort to provide instruments with more accurately divided scales. Here comes the role of STEM education.

STEM education has been introduced in the context of modern museum practices and pedagogical innovation. Science museums and science centers are an important component of STEM education as a whole (National Research Council, 2009) since students are encouraged to apply science and engineering practices and recognize cross-cutting concepts. Science museums, science centers, zoos and botanical parks have played a decisive role in developing STEM education programs for children and young people.

Recognizing the value of the endeavor, the US Department of Education provided new funding for equipping science centers offering STEM activities (Friedman, 2019). However, STEM education based on objects with a historical cultural importance is still limited. In his study, Krull (2017) provides evidence that the merging of an object-based education method with STEM learning standards can offer a set of rewarding educational lenses through which K-8 students can be taught history, culture and the STEM fields.

There is now sufficient evidence that collections of historical instruments, science museums and science centers provide an adequate context for students' STEM education. One issue needs further consideration, however, and this relates to the training of teachers in STEM education. Here, teacher education programs need to be reviewed so they include integrated STEM preparation, and further training needs to be provided to in-service teachers–or at least to those who intend to incorporate STEM activities into their classroom practice.

In recent years, the authors have attempted to introduce MTC's collection of scientific instruments as an educational environment in both formal (Stefanidou et al., 2023) and informal (Lazos et al., 2022) science education, engaging school students, undergraduates and post-graduate students as well as the public, and giving rise to new ideas regarding STEM education.

PERSPECTIVES & EXPECTED RESULTS

Considering the current trends in the interdisciplinary approach to STEM, the need to train teachers in the STEM approach and to cultivate awareness of issues related to the preservation and valorization of our scientific heritage, we are looking to design and implement an in-service STEM education program for science teachers. Once the bibliographic documentation and historical identification of the surviving historical scientific instruments are complete in their natural place, a STEM education program will be designed. Based on the preservation and reconstruction of the scientific instruments, the program will promote the value of our scientific heritage. The project is intended to include an online catalogue, which provides exhaustive descriptions of the scientific and technical heritage (short videos or virtual 360º) and educational activities. Everything is open access for teachers, students, and the public (formal & informal learning).

The STEM education program under consideration, which is to be designed for science teachers, is explicitly inspired by the history of the scientific instruments, and particularly their design, functioning and use. It will be based on real problems relating to the preservation and maintenance of historic scientific equipment. For instance, participants could work on a defective hydrostatic balance (**Figure 6**) or a manual vacuum pump (**Figure 7**).

Figure 6. Hydrostatic balance (Photo by P. Lazos)

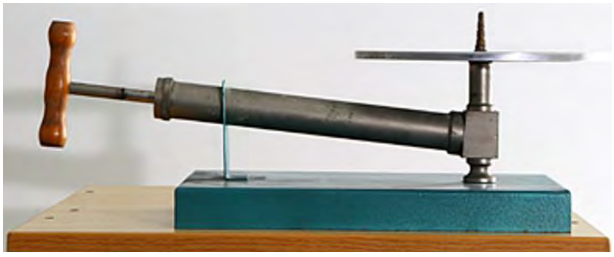

Figure 7. Manual vacuum pump (Photo by P. Lazos)

The reasoning behind the activities will be, as follows: Once science teachers have identified the instruments' deficiencies they will propose possible ways of preserving or rendering them functional to the research team (the authors). The latter will then communicate the science teachers' ideas to experts, whose professional opinion will be sought. As historical instruments are scientific heritage and hence protected, the science teachers will not intervene in them physically. STEM activities will be geared towards overcoming problematic situations, thus fostering the science teachers' critical thinking skills in relation to authentic problems. Solutions will be provided, which make use of everyday materials or state-of-the-art technology (i.e., 3D printers). Through the STEM education project, science teachers will have the opportunity to develop their design engineering skills and to familiarize themselves with the cultural aspects of science.

CONCLUSIONS

This paper aimed at promoting research in the field of the cultural heritage preservation, contributing to the historical documentation of scientific instruments in use at MTC in Athens in the 19th and 20th centuries in terms, too, of their construction, use and operation. Moreover, the paper aimed to investigate the possibility of a STEM education environment in the context of MTC and particularly the collection of historical scientific instruments. Recent research in the field of science education supports the idea of STEM education including history of science, enhancing the relation between scientific knowledge and skills, with the cultural aspects of science. In the case of MTC, this relation could be even stronger, due to the fact that the historical building of MTC houses nowadays the Department of Primary Education and the corresponding post-graduate programs, bridging the gap between the past and the present. As a result, some guiding ideas are discussed regarding in-service teachers STEM education, in the context of the history of scientific instruments in MTC, contributing to culturally contextualized scientific and technological literacy.

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