Mem. S.A.It. Vol. 95, 26
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Memorie della

Large Scientific Infrastructures enriching online and digital Learning

Introducing Astronomy and robotic telescopes to the classroom: An exploratory study

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Received: 1 December 2023; Accepted: 17 January 2024

Abstract. This study explores the benefits of using large scientific infrastructures in education for the students and various ways of support for educators, utilizing the Faulkes Telescope Project's network of robotic telescopes. To investigate whether this approach enhances students' intrinsic motivation, interest in a future science career and collaborative problem-solving skills, a total of 432 matched pre-post questionnaires, built in 5-point Likert scale, were collected from the students who participated in the designed activities. In this paper, we also study the impact of a five-day teacher training that promoted the involvement of robotic telescopes and astronomy in education. The 20 European educators that participated, designed their own activities and filled out pre and post questionnaires that included a combination of multiple-choice and open-ended questions. The data were analyzed using statistical methods and qualitative content analysis.

Key words. science education, astronomy education, large scientific infrastructures in education

1. Introduction

The pandemic crisis affected the landscape of formal education worldwide. While the necessary shift to online learning was made quickly, the majority of the teachers were hardly prepared for it. Teachers had not only to be fluent in the use of Information and Communication Technology (ICT), including online communication platforms and learning management systems, but also had to face a new school reality, that of the virtual classroom (Wut & Xu 2021). One of the main challenges that teachers had to face was to keep students motivated and interested (Gurung 2021). Science teachers also had to find creative ways to organize and implement laboratory work from a distance, utilizing in some cases simple materials to demonstrate experiments from their camera or browsing the web to find appropriate high quality digital tools and resources in order to support their practice (Fox et al. 2020). Last but not least, the desired goal of increasing students' science motivation and fascination and attracting them to science careers, through the implementation of project based learning activities, was put in a stalemate.

The direct interaction of students with science, or the act of doing science, provides learners with personal experiences they can build upon in their own ways. Through the operation of robotic telescopes, students take an active role as researchers, seekers and ultimately leaders of the scientific quest. It is thus expected that by offering this opportunity to students within the context of school curriculum, one can both motivate them to engage in the daily school lessons, even from a distance, and increase their science motivation (Osborne et al. 2003) as they see that the curriculum knowledge can be directly applied to understand the secrets of the heavens. It should be noted that robotic telescopes solve a series of practical issues for the introduction of astronomy in education. Some of those are that astronomical observation usually occurs at night while students go to school during the day (Percy 2003), most students live in light polluted areas and schools cannot afford to purchase the necessary equipment. At the same time, students' interaction with telescopes can provide insights on "how science works" beyond the typical approach that is usually highlighted through the schools' textbooks. It can also be inspiring and showcase the way different fields of science are connected (Gomez & Fitzgerald 2017). In this context the Faulkes Telescope Project[1] provides access to research-class telescopes for educational use within the aim of engaging students in Inquiry-based Science Education and STEM (Science, Technology, Engineering and Math) subjects. It has supported plenty of educational projects where students conduct their own astronomical research (Roberts et al. 2013).

In this framework, this study explores whether the introduction of large scientific infrastructures in education is beneficial for the students and can be supported by the educators. In this case, the network of robotic telescopes provided by the Faulkes Telescope Project was used. The Faulkes Telescope Project was established to inspire young students to study and take part in real science, providing over 1000 hours of observing time per year, on robotic telescopes, including two 2m astronomical telescopes, one on the island of Maui in Hawaii (Faulkes Telescope North) and the other one at Siding Spring in Australia (Faulkes Telescope South). The telescope time is freely available via the Internet to schools and provides *live* astronomical observing directly from the classroom, or via queued observations. The telescopes were originally funded by the Dill Faulkes Educational Trust (DFET) but now are owned and maintained by Las Cumbres Observatory (LCO).

2. Methodology

2.1. Teacher training and activity implementation

Teachers from Greece, Portugal, United Kingdom and Austria were trained through exemplary activities and hands-on workshops that promoted the involvement of robotic telescopes and Astronomy in education. They designed and/or implemented their own educational scenarios that are connected with their countries' curricula. In this paper we study the case of the LaSciL Winter school, which was a five-day training organized for educators from all over Europe. The course was implemented on February 2023 at the Observatorio Lago

[1] faulkes-telescope.com (last visited on 8th of January 2024)

Fig. 1. Students of the 9th Primary school of Komotini compose colored images of M57 with images captured from the one-meter robotic telescope of the Faulkes Telescope Project.

Alqueva in Portugal. It mainly consisted of workshops on astronomical observations with robotic telescopes of the Faulkes Telescope Project and free tools for image analysis (like Salsa J, GIMP and AstroImageJ). It also included hands-on work with tools that can support teachers in remote learning activities (Padlet, Mentimeter, Wordwall, Pixelruler, CODAP etc.) and in introducing Astronomy to their classroom (such as Stellarium, Heavens Above, Google Earth).

Teachers trained by the team as well as members of the team themselves, implemented Astronomy and robotic telescope-related activities with students in their national schools. Some examples of such activities are live observations with the Faulkes Telescope Project and composition of colored images (Figure 1). The activities were implemented in schools from four European countries (United Kingdom, Greece, Portugal and Austria).

2.2. Instruments and sample

To assess the impact of the implemented activities to the students' intrinsic motivation, interest in a future science career and collaborative problem-solving skills, questionnaires that include validated tools (LaForce et al. 2017; Chen et al. 2019) were filled out by the participants before and after the activity. The questionnaires consisted of 14 questions, built in 5-point Likert scale and were translated in the students' native languages (Greek, Portuguese and German).

A total of 1.326 students participated to activities and filled out pre-post questionnaires. The 432 (33%) of those were matched and then

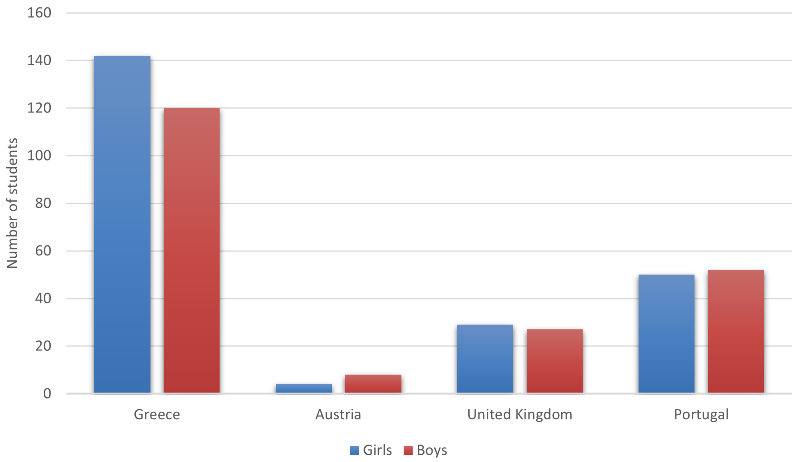

Fig. 2. Gender and country of origin of the sample of students that participated in the study.

analyzed using SPSS[2]. Figure 2 shows the gender and country of the participating students. A greater number of Greek teachers implemented activities in their classrooms, distributing and collecting more questionnaires from their students in comparison with teachers from other countries. At the same time, some Austrian teachers faced difficulties promoting the questionnaires.

To evaluate the effectiveness of the teacher training courses, pre and post questionnaires were created and filled out by the educators who participated in those courses. These questionnaires consisted of 20 open-ended and multiple choice questions and were used to assess the training's impact on the educators' interest, confidence and ability to incorporate Astronomy and robotic telescopes in their classroom. The teachers' familiarity with digital tools that can support and enhance their teaching, as well as their ability to incorporate them in an activity were also evaluated. During the LaSciL Winter school, 20 teachers from all over Europe participated in the training.

[2] SPSS is a program for statistical analysis in social sciences. Amongst others it is widely used for quantitative data analysis in education research (Connolly 2007).

3. Results-Discussion

3.1. Students

As suggested by previous authors (Osborne et al. 2003), the conducted paired sample t-test indicated a small but significant increase in the students' intrinsic science motivation after the activity compared to before (t(431)=2.07, p=0.039). Their interest in a future science career (t(431)=1.94, p=0.053) and collaborative problem-solving skills (t(431)=1.54, p=0.125) were also increased but the difference is not statistically significant (Figure 3). Also, as demonstrated in Figure 4, the independent sample t-test between girls and boys showed that boys had higher intrinsic science motivation after the activity compared to the girls (t(426.37)=2.75, p=0.006). The same applies for the boys' interest in a future science career after the activity compared to the girls' (t(429.54)=2.53, p=0.012). Due to the variety of the implemented activities, not all of them included collaborative work between the students. Consequently, it was expected that their collaborative problem-solving skills might not be improved.

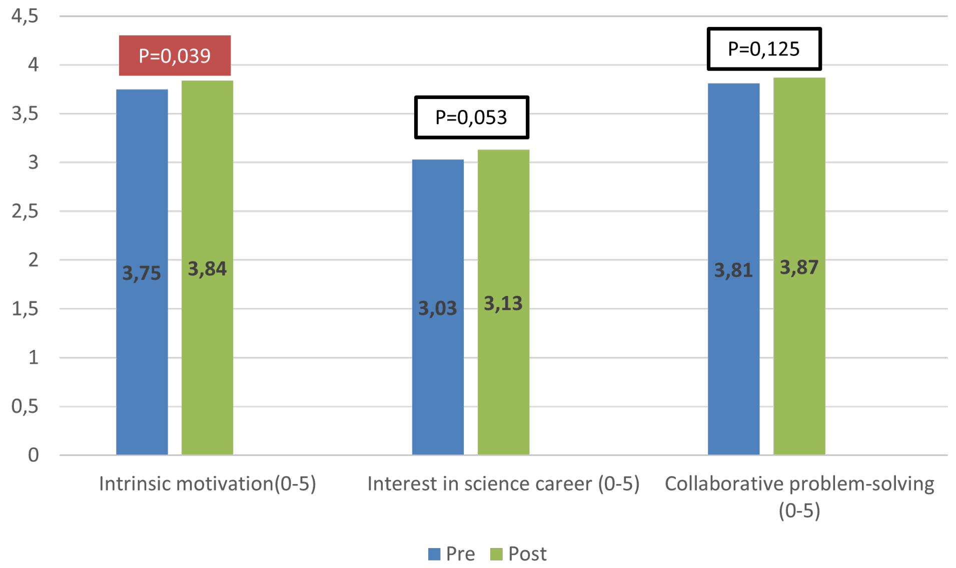

Fig. 3. A paired sample t-test was conducted, using SPSS, to compare the students' scores before and after the activities. Median values of the 5-point Likert scaled questions before and after the intervention, as well as the p values of the paired t-test are shown in the figure.

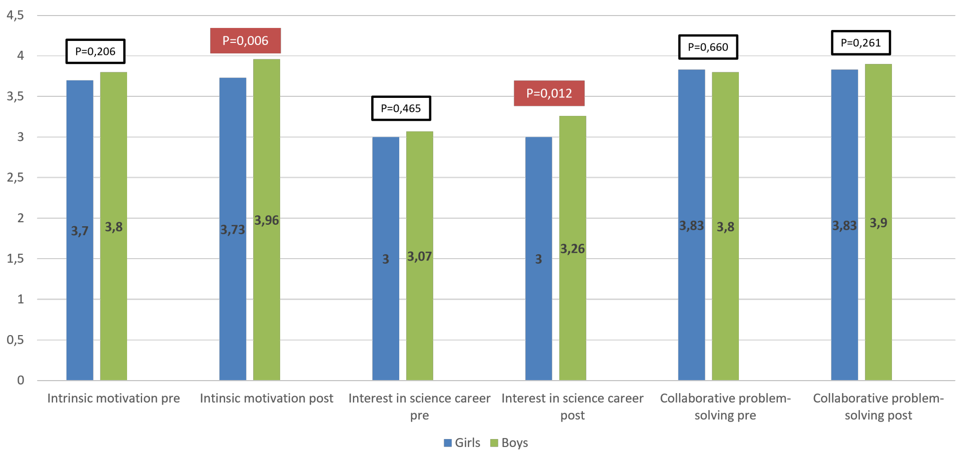

Fig. 4. An independent sample t-test was used to compare between the scores of girls and boys. The Figure shows the median values of each group before and after the activities as well as the p values resulted from the independent sample t-test.

3.2. Teachers

A ceiling effect was recorded on the teachers' interest in incorporating Astronomy into their classroom and their perception of its value, since 90% of the teachers strongly agreed with the respective Likert-scaled sentences of the

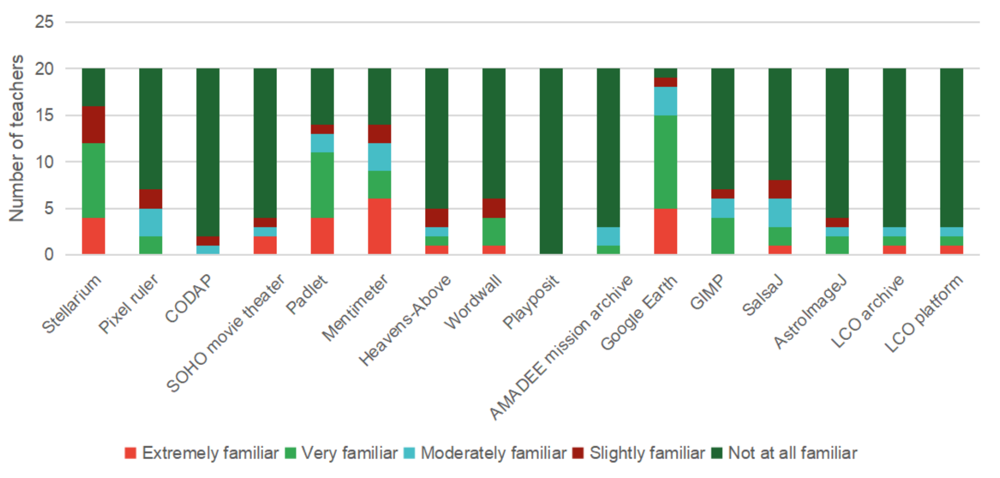

Fig. 5. The self-recorded familiarity of the teachers with the tools that were included in the course, before its implementation.

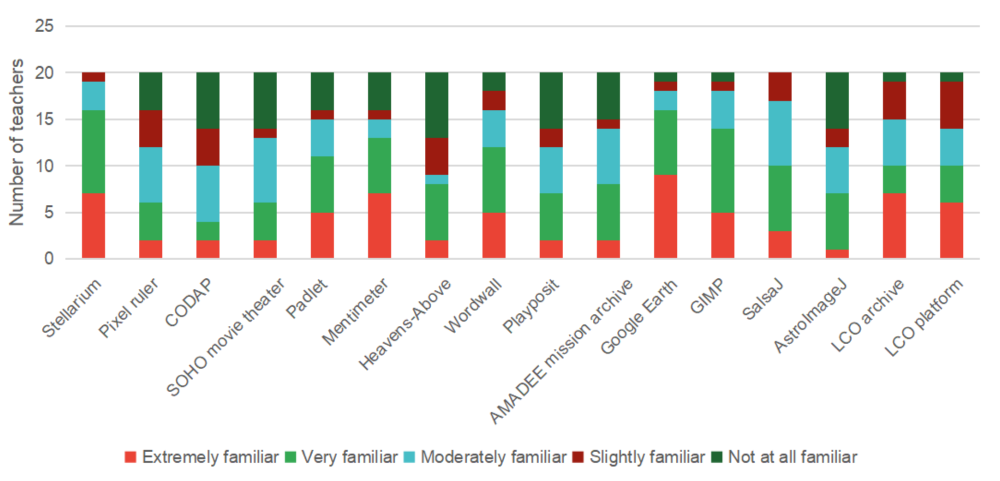

Fig. 6. The self-recorded familiarity of the teachers with the tools that were included in the course, after its implementation.

questionnaires even before the course. This outcome was expected,given their initial interest and willingness to dedicate time to a five-day training in this subject.

As shown in Figures 5 and 6, the educators' familiarity and ability to use the digital tools that were included in the winter school's program were increased.

It should be noted that many workshops were implemented concurrently. This allowed the teachers to choose the workshops they would like to attend based on their prior experiences. The tools attended by fewer teachers showed the least improvement.

Even though the sample size is small, and statistical analysis cannot be implemented, there was a noticeable improvement, as shown from the medians and standard deviation values, in the educators' self-reported ability to use robotic telescopes (Mpre=3, SDpre=1.3, Mpost=4.25, SDpost=1.02), locate pictures taken from them (Mpre=3.35, SDpre=1.35, Mpost=4.55, SDpost=0.83) and integrate them in an educational activity (Mpre=3.5, SDpre=1.24, Mpost=4.4, SDpost=0.88). Additionally, they expressed increased confidence in guiding their students to make their own astronomical observations (Mpre=3.1, SDpre=1.41, Mpost=4.35, SDpost=0.88).

Each participating teacher successfully created an educational activity, utilizing robotic telescopes, aligned with their country's curricula. The majority of them (74%) included some form of image analysis on images obtained by robotic telescopes and almost all the educational scenarios (95%) incorporated at least one digital tool.

4. Conclusions

This study delves into the advantages of integrating large scientific infrastructures, particularly the Faulkes Telescope Project's network of robotic telescopes, into education. The research underscores the significance of supporting educators from diverse European backgrounds through training, allowing them to design and implement educational scenarios aligned with their respective curricula.

The results of this study suggest that incorporating robotic telescopes in education can significantly boost students' intrinsic science motivation. Boys' intrinsic science motivation and interest in a future science career is higher following the activity compared to the girls'. Further research is required to explore the benefits of this approach.

To facilitate the incorporation of robotic telescopes in education, it is considered very beneficial for teachers to participate in training workshops which will allow them to get familiar with different tools and the use of robotic telescopes. This will increase their confidence and allow them to use robotic telescopes, as well as images that have been captured by them, successfully in their classroom and support their students in making their own astronomical observations.

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Acknowledgements. This study was implemented in the framework of LaSciL[3] (Large Scientific Infrastructures enriching online and digital Learning) Erasmus+ project which is a collaborative effort among leading European Universities and research institutions. LaSciL consortium envisions to empower and support teachers to increase literacy and to familiarize with the use of high-quality digital tools and aims to introduce Astronomy and Robotic Telescopes to schools throughout Europe by developing innovative digital learning resources.

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