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VII Workshop on Robotic Autonomous Observatories (October 16-20, 2023)
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DEVELOPING SCHOOL SCIENCE SKILLS THROUGH THE SCIENCE-IES ROBOTIC TELESCOPE PROJECTS

J. R. Girón-Gambero[1]

RESUMEN

Desde 2013, algunos de los proyectos Science-IES en Institutos de Enseñanza Secundaria en Málaga y provincia (España) se centran en el uso de telescopios robóticos y conjuntamente con el resto de proyectos, y se presentan como oportunidades para el desarrollo de habilidades científicas escolares en estudiantes de secundaria y bachillerato, especialmente en lo que respecta a la explicación de fenómenos científicos. También están conectados con el conocimiento de las disciplinas que conforman el enfoque STEM (Ciencia, Tecnología, Ingeniería y Matemáticas), manifestándose esta conexión en mayor medida con la parte científica y matemática.

ABSTRACT

Scince 2013, some of Science-IES (high-schools) projects in Málaga and its province (Spain) focus on the use of robotic telescopes and together with all the other projects are presented as opportunities for the development of school science skills in secondary and high school students, especially with regard to the explanation of scientific phenomena. They are also connected with knowledge of the disciplines that make up the STEM (Science, Technology, Engineering & Mathematics) approach, this connection being manifested to a greater extent with the scientific and mathematical part.

Key Words: education — instrumentation: detectors — methods: observational — telescopes

1. INTRODUCTION

The competency-based vision of education guided by international standards (OECD 2023), aims for students to develop specific competences and STEM competences (mathematical competence and competence in science, technology and engineering) at school stages (MECyD 2022). This development can take place through formal education in the classroom or through school science programmes (Pérez-Cáceres et al. 2017). One of the best known in Andalusia is Science-IES, formerly known as PIIISA (Lupión and Pérez-Cáceres 2017), in which secondary school students work together with scientists from universities or research centres.

ScienceIES is a distinctive way to teach Astronomy and other scientific disciplines, focusing in high-school students (age 15-17). ScienceIES is the name of the project started in 2010 at regional level in Andaluca (south Spain) pulling together the educational and scientific systems with students in the target[2]. Some of the Astronomy projects are based on the use of robotic telescopes (Castro-Tirado et al. 2021), such as the ones of the BOOTES worldwide network (Castro-Tirado 2023).

The approach in the secondary school classroom of transversal practices that integrate Science, Technology, Engineering and Mathematics (STEM) disciplines is complicated and not very viable due to the organisation of the curriculum (Gardner & Tillotson 2019; Toma & Greca 2018), therefore the Science-IES programme is an interesting approach for the development of transdisciplinary STEM scientific knowledge as it is oriented towards problem solving and contextualised in diverse and real situations (Aguilera et al. 2022). While it is true that the programme as a whole was assessed from an educational perspective in a previous edition (Lupión et al. 2022), this is the first time that projects using robotic telescopes are specifically analysed for a wide range of years, in order to determine the degree to which they develop scientific skills (OECD 2023) and contribute to the knowledge of the different disciplines that constitute the STEM educational approach.

2. METHODOLOGY

Since 2013, some of the annual Science-IES projects have been developed with robotic telescopes as the focus (Castro-Tirado et al. 2021). A total of 121 secondary and high school students from secondary schools in Málaga (including the

[1]Facultad de Ciencias de la Educación, Departamento de Didáctica de la Matemática, Didáctica de las Ciencias Sociales y de las Ciencias Experimentales, Universidad de Málaga, Boulevard Louis Pasteur 25, 29010 Málaga, Spain (jrgiron@uma.es).

[2]https://piiisaandalucia.blogspot.com/

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Fig. 1. *Left:* Flare stars high-school students' ScienceIES poster. *Right:* Pluto's atmosphere high-school students' ScienceIES poster.

Fig. 2. *Left:* Meteors and fireballs high-school students' ScienceIES poster. *Right:* The Local Group of Galaxies high-school students' ScienceIES poster.

province) and 11 scientists from two research centres in Málaga and Granada have collaborated closely. The three research centres are: University of Málaga (UMA), Institute of Astrophysics of Andalucía of the State Agency Spanish Research Council (IAA-CSIC) and Institute of Subtropical and Mediter-

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Fig. 3. *Left:* Astrobiology and exoplanets high-school students' ScienceIES poster. *Right:* Solar activity high-school students' ScienceIES poster.

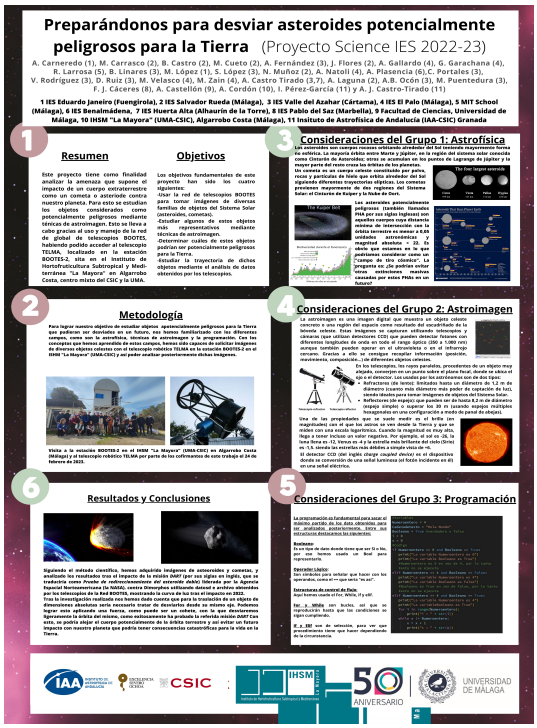

Fig. 4. Potentially hazardous asteroids high-school students' ScienceIES poster. This one and the above mentioned projects have been conducted under the supervision of A. J. Castro-Tirado (IAA-CSIC and UMA).

ranean Hortofruticulture La Mayora (IHSM\UMA-CSIC). In order to assess the educational interest of these projects, the scientific posters (Figures 1-7) were used as a source of data, as they had been prepared by the students following the usual scientific dissemination structure of real science congresses. In the didactic analysis procedure, the PISA 2025 Framework (OECD 2023) is taken as a reference, which establishes three main scientific competences that, in turn, are broken down into skills that, as a whole, determine the students' degree of competence. In this research, achievement indicators have been designed for each of the Framework´s competences, so that the contribution of the projects as a whole to the development of scientific competences can be studied (Tables 1-3). Moreover, due to the specific nature of the procedures followed in the robotic telescope projects, it is possible to link these indicators to dimensions of the STEM competence, for example: the use of specific software is linked to the "E" of Engineering or the use of astronomical magnitudes to the "M" of Mathematics (Tables 1-3).

3. RESULTS

All the projects develop the capacities established by the PISA 2025 Framework, based on the indicators detected in each of them (Tables 1-3).

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Table 1. Contribution of the projects to the development of the scientific competence "Explaining phenomena scientifically".

1. Explaining phenomena scientifically		
Capacities	*Indicators*	*STEM*
Recall and apply appropriate scientific knowledge	Uses laws and theories of astronomy	S
	Uses astronomical magnitudes and units of measure	M
	Describes telescopes according to their technical characteristics	E
	Applies specific formulas	S
Use different forms of representations and alternate between them.	It represents complex parameters (light curve, Wolf number...) and corresponds to real images provided by telescopes.	E
		M
Recognise and develop explanatory hypotheses for phenomena in the material world	Indicates problem or hypothesis in introductory part	S
Explain the potential implications of scientific knowledge for society.	Outlines in conclusions the implications for society	T
		S

Fig. 5. Contribution of the projects to the development of the scientific competence “Explaining phenomena scientifically”.

Table 2. Contribution of the projects to the development of the scientific competence "Constructing and evaluating scientific research designs and interpreting scientific data and evidence critically".

2. Construct and evaluate designs for scientific research and interpret scientific data and evidence critically.		
Capacities	*Indicators*	*STEM*
Identifying the question in a specific scientific study	Set concise objectives	S
	It draws conclusions that respond to the objectives	S
		E
Interpret data presented in different representations, draw appropriate conclusions from the data and evaluate their relative merits.	Analyses telescope images of celestial bodies	S
	Includes and interprets electromagnetic spectra or complex graphs	M
	Specifies a procedure in methodology for analysing data	T
	Uses specialised software to obtain data	E
	Drawing conclusions based on astronomical data	M

Fig. 6. Contribution of the projects to the development of the scientific competence “Constructing and evaluating scientific research designs and interpreting scientific data and evidence critically”.

The most important skill to develop is “remembering and applying appropriate scientific knowledge”, which transcends school science and is specific to the researchers with whom the pupils collaborated.

The skill it contributes most to developing is “Interpret data presented in different representations, draw appropriate conclusions from the data and evaluate their relative merits”, extracted from complex measuring devices used by scientists in their research.

This competence is developed to a lesser extent, with scientific arguments constructed using complex scientific data appearing.

The projects contribute to the development of the three scientific competences, but when analysed

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Table 3. Contribution of the projects to the development of the scientific competence "Investigate, evaluate and use scientific information to make decisions and take action".

3. Research, evaluate and use scientific information to make decisions and take action.		
Capacities	*Indicators*	*STEM*
Construct an argument to support an appropriate scientific conclusion from a set of data.	Includes sentences with scientific arguments	S

Fig. 7. Contribution of the projects to the development of the scientific competence “Investigate, evaluate and use scientific information to make decisions and take action”.

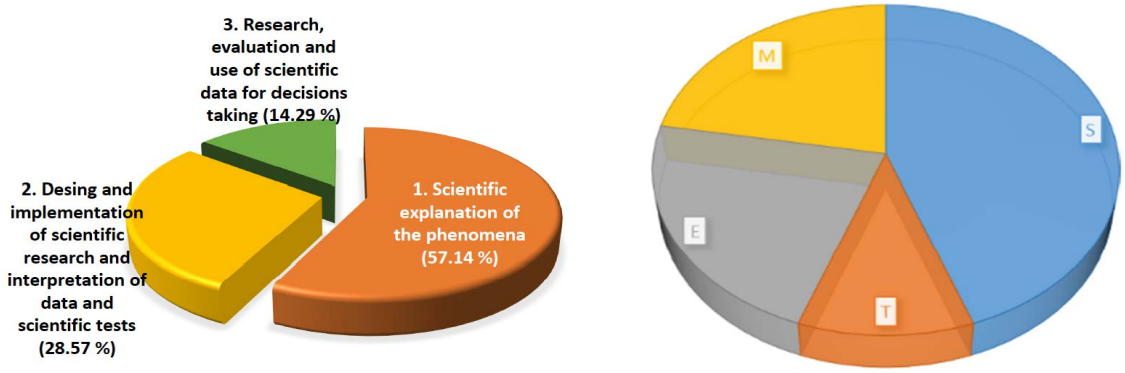

Fig. 8. *Left:* Overview of the contribution of projects to the development of scientific competences. *Right:* Connecting the projects to the different disciplines of the STEM education approach.

on the basis of the indicators, the relative weight between them is unequal (Figure 8, left).

Finally, the analysis of the indicators also provides information regarding the connection of the projects with the different disciplines of the STEM education approach (Figure 8, right).

It appears that these projects are connected to a greater extent with the scientific and mathematical part of STEM.

4. CONCLUSIONS

Science-IES projects that focus on the use of robotic telescopes are presented as opportunities for the development of school science skills in secondary and high school students, especially with regard to the explanation of scientific phenomena. They are also connected with knowledge of the disciplines that make up the STEM approach, this connection being manifested to a greater extent with the scientific and mathematical part. It is therefore necessary to continue this collaboration between astrophysicists and schoolchildren in order to provide a stable framework for the development of scientific skills in the context of astronomy.

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