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In-Service Teacher Training on Inquiry-Based Learning: Using Astronomy as a Gateway Science in Formal Education

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Abstract

"Inquiry-Based Learning (IBL) with Digital Resources", organised by Porto Planetarium - Ciência Viva Center, is a free in-service teachers' training workshop, accredited for career advancement. It introduces teachers to IBL methodology, challenging them to develop an IBL lesson plan. Participants must also create an educational digital resource and are encouraged to use astronomy as a gateway science to teach the national syllabus. To analyse teachers' work during the workshop, a case study was conducted, applying content analysis to twelve lesson plans. The results showed that 58% of the participants were Physics and Chemistry teachers. 92% of the participants implemented IBL in their classes, developing astronomy-related problems. Among these, 64% used collaborative work to address IBL. All teachers provided orientations through work guides or oral instructions. Text documents, used as work guides, accounted for 43% of the digital resources developed. Four lesson plans were interdisciplinary. Notably, 42% of the participants taught non-physics-related subjects, suggesting that IBL facilitates astronomy's integration across different school subjects. Teachers assumed a guidance role, supported by digital resources, while students cooperated towards the solution. Although not required, interdisciplinary plans were developed, revealing that IBL promotes teachers' creativity, contributing to collaborative learning. Analysis of additional lesson plans could further validate the benefits of IBL, particularly its capacity to support astronomy integration. Moreover, understanding how teachers apply the knowledge from in-service teachers' training helps assess their overall impact and co-design the training.

Keywords: Inquiry-Based Learning, Gateway Science, In-Service Teacher Training, Astronomy Education

1 Introduction

In 2018, the Portuguese education system underwent a major curricular revision, introducing Essential Learnings (EL), a set of common knowledge, skills and attitudes to be developed in each school subject (Presidência do Conselho de Ministros, 2018). Despite the introduction of the new curriculum documents, the presence of astronomy-related topics in compulsory education has diminished (Costa et al., 2025) across the 1st – 8th grades, with only 25 EL directly addressing astronomy, with 10 EL concentrated in the 7th grade Physics and Chemistry curriculum, under the Space theme (Costa et al., 2025). As interest in astronomy typically develops at an early age (Dang and Russo, 2015), the lack of exposure to the field can compromise the future of astronomy research in Portugal. In this context, Porto Planetarium developed the Inquiry-Based Learning (IBL) with Digital Resources workshop, a free in-service teacher training activity, accredited for career advancement (Porto Planetarium, 2025). This workshop, conducted annually since 2021, introduces teachers to IBL methodology, considering a four-stage process: Engage (problematization), Explore, Explain, and Communicate. The teachers are then asked to develop an IBL lesson plan and an educational digital resource for it. Participants can choose any theme to implement IBL but are encouraged to use astronomy as a gateway science to teach the curriculum by developing a problem that connects astronomy to the ELs. This study aimed to understand how teachers applied the competences developed during the workshop and whether the IBL methodology could be effectively used to incorporate astronomy into formal education.

2 Methodology

In Portugal, teachers are divided into recruitment groups according to the subjects they are legally allowed to teach. The workshop was targeted to four recruitment groups: "Physics and Chemistry", "Biology and Geology", "Geography", and "Mathematics and Natural Sciences" teachers. The former three groups can teach 7th through 12th grades, while the latter can teach 5th and 6th grades. The sample consisted of 12 lesson plans developed due to a single workshop session during the 2022/2023 school year. A content analysis was used to examine the lesson plans (Table 1).

Table 1. Content analysis applied to the lesson plans. Credit: Authors

Category [Subcategory]	Element Analysed
Participants [Teachers]	Recruitment Group
Participants [Students]	Grade | Learning Setting
IBL [Engage]	Problems' Theme
IBL [Explore]	Students' Organization | Information-Gathering Strategy
IBL [Explain]	Students' Organization | Findings' Reporting Format
IBL [Communicate]	Findings' Communication Mode
IBL [Logistics]	Materials
Digital Resources	Type | Stage of Use (IBL)
Interdisciplinarity	Subjects | Subjects' Intervention

3 Results

3.1 Participants

Physics and Chemistry teachers comprised 58% of the participating teachers. Geography teachers were the only group not to enroll in this session. Each teacher implemented their plan with a group of students of the same age, with a wide variety of grade levels being observed. Only one teacher did not implement their plan in a formal school setting, having worked with students at a tutoring center (Figure 1).

3.2 IBL

IBL methodology was successfully implemented in 92% of the lesson plans. In total, 15 problems were developed. Some teachers opted to work more than one problem with their students. Six themes were identified, with some plans addressing more than one theme (Table 2).

Table 2. Themes assigned to the developed problems through content analysis.

Theme	Frequency
Stars' Chemical Composition	3
Physical and Chemical Properties of Planets	4
Space Technology	2
The Life of Astronauts in Space	1
Existence of Life on Earth	3
Geology of Celestial Objects	4

The students' organization was kept equal during the Explain stage. The students used the internet as their primary research tool, particularly under teacher guidance. Writing a report was the most common way the students reported their findings (Figure 2).

In 81% of the cases, students shared their findings only with their peers. Online resource sharing, such as uploading a report to the class forum, was the primary means of communication (Figure 3).

School materials and information technology equipment were indispensable to the implementation of all plans.

3.3 Digital Resources

The most common digital resource developed was text documents (43%). The digital resources were mainly used during the Explore stage, either alone or in combination with other IBL stages, with eleven resources serving as work guides, designed to instruct students on how to conduct their findings (Figure 4).

3.4 Interdisciplinarity

Four interdisciplinary lesson plans were developed, one by a Physics and Chemistry teacher, and the others by Biology and Geology teachers. Five types of interdisciplinary intervention were observed (Table 3).

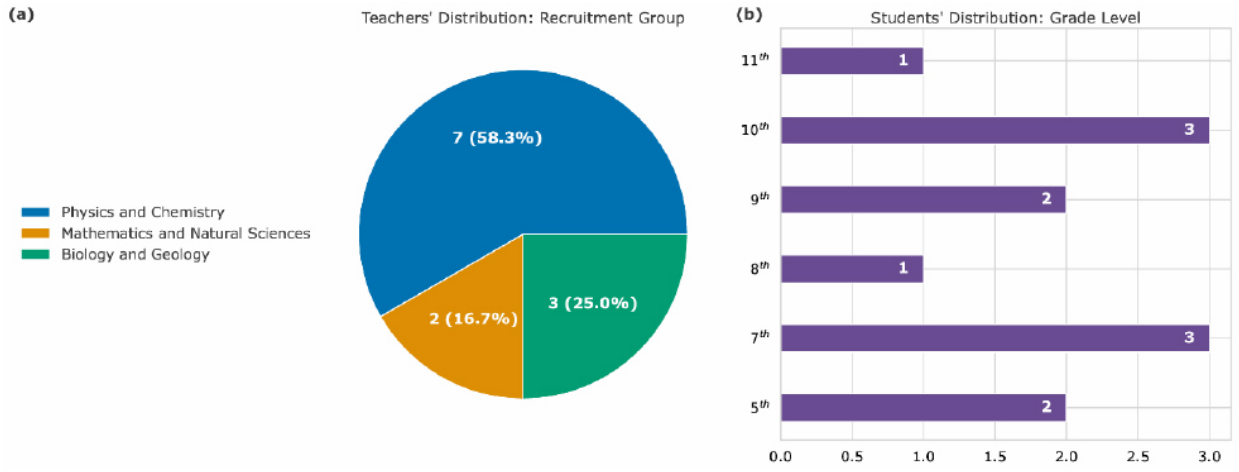

Figure 1. Distribution of participating teachers by recruitment group (a). Students' distribution by grade level (b). Credit: Authors

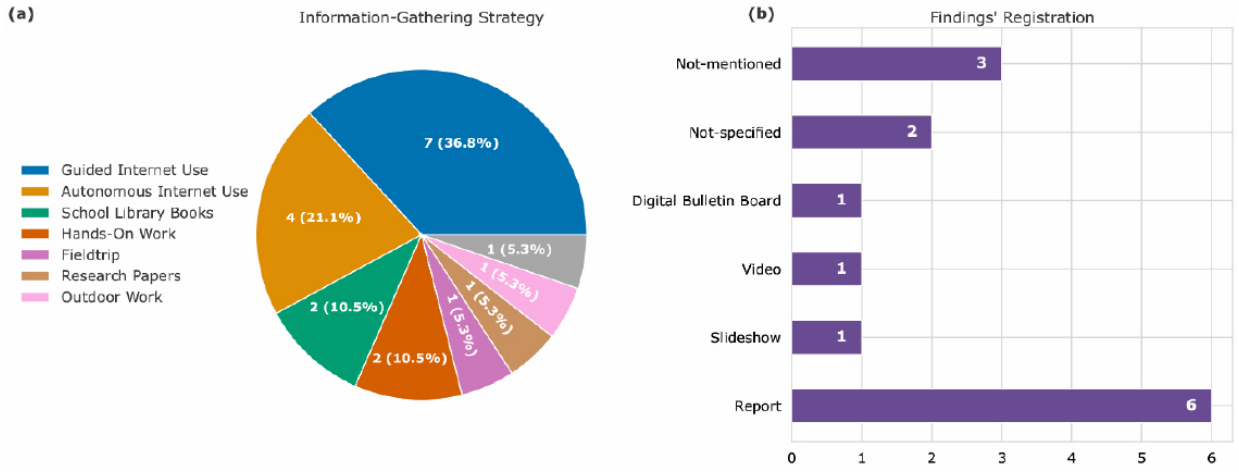

Figure 2. Information-gathering strategy used by students in the Explore stage (a). Reporting format created in the Explain stage (b). Credit: Authors

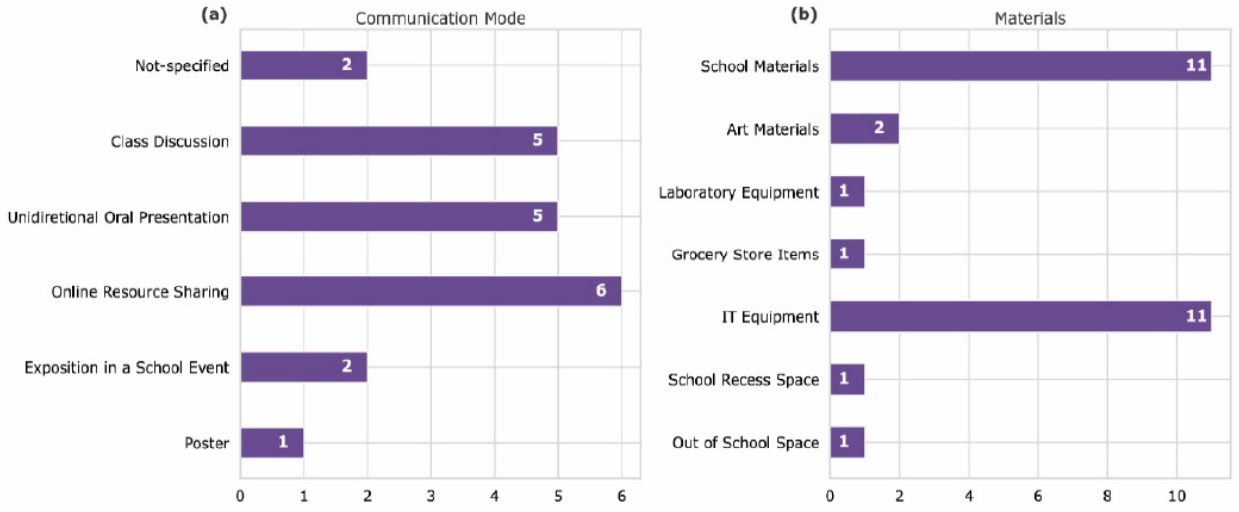

Figure 3. Mode of communication of the findings (a). Materials needed to implement the plans (b). Credit: Aurthors

3.5 Discussion & Conclusion

All teachers were capable of using astronomy as a gateway science to teach their syllabus, having constructed problems that connected the curriculum to astronomy, regardless of their recruitment group or students' grade level. This shows that IBL methodology can help students to work astronomy-related content across different grade levels, and its use with this strategy is not restricted to fields commonly associated with astronomy, such as Physics. IBL can facilitate the integration of astronomy into the classroom, especially when these topics are lacking in the curriculum. Collaborative work and guided internet use were the primary strategies for implementing IBL, with report-making and peer communication being privileged. In this con-

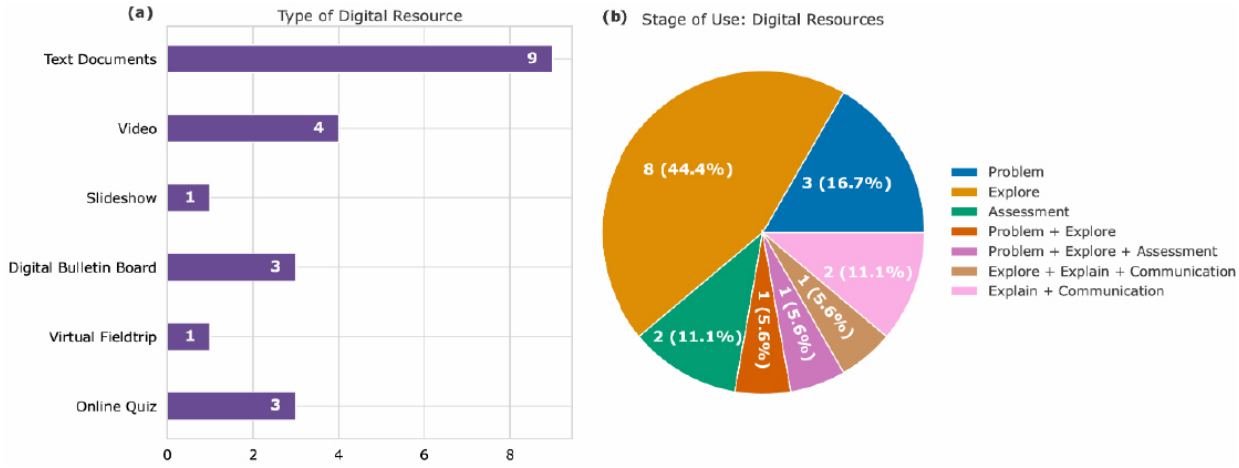

Figure 4. Results of the content analysis for the "Digital Resources" category. Credit: Aurthors

Table 3. School subjects present in the interdisciplinary plans and their intervention in the plans. Own production.

Intervention	Subject	Frequency
Oversight of the written work (Explain).	Portuguese	4
Oversight of the artwork (Explain).	Art	1
Supporting the use of IT equipment.	Communication and Information Technologies	1
Applying knowledge from the IBL lesson plan to another subject.	Mathematics; Geography; Art; Technological Education; Portuguese	1
Exploring the theme of the IBL lesson plan in another subject.	English; Citizenship and Development	1
Inclusion measures.	Inclusive Education	1

text, teachers assumed a supervisory role, supported by digital resources, while students cooperated to reach the solution. The development of interdisciplinary plans, although not mandatory, suggests that IBL lessons open the door to collaboration across subjects and to more creative approaches to the syllabus. Additionally, teachers can share their IBL lesson plans through a webpage, making them publicly available to interested teachers and encouraging the use of this methodology. Further analysis of lesson plans from other editions of this workshop could help validate the benefits of IBL, observed in this sample. Examining the products of in-service teacher training activities provides insight into what actually reaches the classroom, paving the way for improving future initiatives.

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