Challenges of Pre-service Physics Teachers in Implementing Authentic Argument Driven Inquiry (AADI): A Three-Phase Study

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Abstract. The researchers designed and implemented Authentic Argument Driven Inquiry (AADI) activities in an undergraduate elective course to reveal challenges faced by pre-service physics teachers (PPTs) in AADI activities. The course was structured into three phases: learning, preparation, and teaching. This study specifically focused on three PPTs with the lowest performance, out of ten taking the course. Data sources included video recordings of the class sessions and interviews with the participants, materials of the course, and reflection papers. Data analysis revealed that challenges differed for each PPT across phases and activities due to the content-dependent nature of the relevant skills involved.

Introduction

Bruner[1], a key figure in science education, stresses the idea that, for conceptual learning to occur, learners should act like scientists do. With his own words "[t]he schoolboy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else." The National Science Education Standards[2] echoes this situation, emphasizing that students, by questioning natural events and seeking answers like scientists, develop a profound understanding of scientific laws, theories, models, and principles. Kuhn[3] emphasizes that inquiry and argumentation activities in classrooms provide an environment conducive to this type of learning.

In science education, one of the instructional methods that integrate both inquiry and argumentation is Argument Driven Inquiry (ADI)[4]. In this research, ADI was revised to enhance authenticity, and the steps involving argumentation and inquiry were reorganised to reflect the nature of scientific inquiry. This revised version of ADI as used in this research was termed Authentic Argument Driven Inquiry (AADI).

Following an extensive literature review, it is clear that a key concern in science education is the implementation of inquiry and/or argumentation activities in learning environments. Some researchers have delved into the reasons behind their limited use, with studies predominantly attributing infrequent implementation to external barriers such as time constraints[5] and insufficient resources[6]. However, internal challenges associated with teaching using these activities have not undergone a comprehensive analysis.

Before identifying the internal challenges confronted by teachers in applying AADI, it is methodologically prudent to first examine the internal challenges faced by pre-service teachers (PPTs), who are future educators. Thus, the study aims to clarify the challenges encountered by PPTs in various roles: as learners in AADI activities, as creators of AADI activities, and as teachers in implementing AADI activities where external barriers have been effectively addressed. In this regard, the following research questions are formulated:

RQ1. What are the challenges of PPTs in physics-oriented AADI activities?
- RQ1.1 What are the challenges of PPTs acting as learners in AADI activities?
- RQ1.2 What are the challenges of PPTs acting as creators of AADI activities?
- RQ1.3 What are the challenges of PPTs in acting as teachers in AADI activities?

Methods

For the purpose of this study, an under graduate elective course was re-designed to implement AADI activities developed by the researchers. The course consisted of three phases: the learning phase, where the PPTs acquired knowledge and participated in AADI activities as students; the preparation phase, where each PPT created an AADI activity; and the teaching phase, where the PPTs conducted activities as instructors on three occasions. Materials of the course used in the learning phase were developed beforehand by the researchers. This study is being carried out with three lowest-achieving PPTs enrolled in the course. Two of them were junior students and one was sophomore student.

All lessons were video-recorded. Following each AADI activity and phase, video-recorded interviews were conducted with the PPTs. Video records, course materials and reflection papers were utilized as data sources.

Data analysis of the study highlighted challenges related to argumentation skills, science process skills, and conceptual understanding. Challenges related to science process skills and conceptual understanding were identified as precursors to challenges related to argumentation skills. Consequently, this study specifically focuses on presenting findings related to challenges in argumentation skills, utilizing Toulmin's Argument Pattern (TAP)[7] as a structural model. The study includes both empirical and theoretical argumentation sessions, using the terms "empirical" and "theoretical" to precisely specify the nature of the argumentation session where a challenge arises.

Conclusion

Data analysis revealed the following findings: (1) Challenges in the learning phase included formulating and presenting claims, empirical data, and empirical rebuttals; (2) Challenges in the preparation phase involved constructing theoretical data and theoretical warrants; (3) Challenges in the teaching phase encompassed guiding through claim, empirical data, theoretical data, empirical warrants, and theoretical warrants; (4) Challenges varied for each PPT across phases and activities; (5) Proficiency in argumentation or science process skills as a PPT did not assure mastery in all content areas; (6) Success as students in the AADI activities did not guarantee success as teachers in the AADI activities.

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