

EXPLORING PRE-SERVICE PRIMARY TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE OF INTERDISCIPLINARITY IN SCIENCE AND MATHEMATICS

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Abstract

This study examines the pedagogical content knowledge (PCK) of pre-service primary teachers enrolled in a two-year master's program in Primary Education (1st to 6th grades) with a specialization in Mathematics and Sciences. The primary objective is to investigate changes in their PCK regarding interdisciplinarity in science and mathematics following participation in a lesson study. This paper corresponds to an exploratory phase of the study, focusing on the analysis of PCK prior to the implementation of the lesson study. Data was collected through an open-ended questionnaire administered before the lesson study. This questionnaire aimed to capture the specificity of pre-service teachers' understanding of interdisciplinarity by exploring their knowledge and examples of activities that promote the integration of these two areas.

Preliminary results indicate that initially, the pre-service teachers possessed a limited perspective on interdisciplinarity, characterized by uneven connections between science and mathematics. There was a significant emphasis on content, primarily focusing on knowledge to be explored interdisciplinarily, with less attention given to skills and attitudes. Mathematics was predominantly integrated through data processing within sciences activities. Furthermore, only a few participants viewed interdisciplinarity as a meaningful integration, where both disciplines collaborate to support one another, thereby enabling unique learning experiences.

Keywords: Interdisciplinarity; Pre-service primary teachers; Lesson study; Pedagogical content knowledge

INTRODUCTION

Future teachers should be able to make connections between different disciplines. An interdisciplinary approach encourages deeper understanding overtime, inter-relating different topics or subjects (OECD, 2019). That implies careful planning in how and when the topics of each subject will be explored, to promote connections between them.

However, the implementation of interdisciplinarity in schools faces problems of different kinds (e.g. Johnson & Czerniak, 2023). The interdisciplinary work between Science and Mathematics will always involve the mobilization of disciplinary knowledge from, at least, these two disciplines and depends upon teachers' pedagogical content knowledge (PCK) of each discipline (Ríordáin et al., 2015) and their possible intersections, denominated interdisciplinary pedagogical content knowledge (IPCK) (An, 2017). A way to support teachers practiced professional development regarding interdisciplinarity is through lesson study (Tomkelski et al., 2022).

The central framework of lesson study comprises four key moments: i) characterization of the context and definition of a goal for the development of the research lesson; ii) planning, that is, collaboratively designing

a lesson on a specific curriculum topic through multiple sessions with a group of teachers; iii) research lesson, that corresponds to the implementation of the planned lesson in a classroom setting.; and iv) post-lesson reflection, when the group of teachers meets to discuss and reflect on the students' actions in the research lesson, based on observations recorded (Tomkelski et al., 2022). Figure 1 presents the lesson study cycle constituted by four phases.

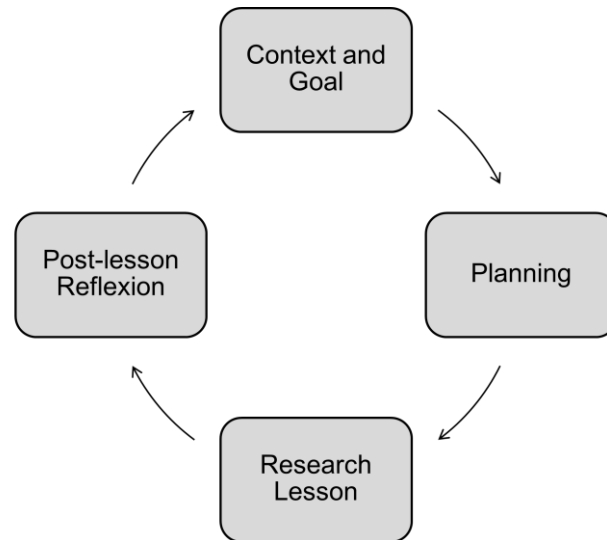


Figure 1. Lesson study cycle of the investigation (Adapted from Tomkelski et al., 2022)

Lesson study provides opportunities for pre-service teachers to strengthen their understanding of content, pedagogy, and student learning, namely skills and knowledge in science and mathematics education (e.g., Kraft et al., 2024; Martins et al., 2023). For instance, Martins et al. (2023) involved mathematics pre-service teachers in a lesson study and concluded that this process allowed them to refine their teaching strategies, leading to improved practice and a better understanding of how to promote students' mathematics reasoning. Kraft et al. (2024) in an extensive review of the literature on lesson studies in science teacher preparation programs concludes that lesson study is a transformative process, enriching pedagogical and content knowledge.

This study explores the pedagogical content knowledge (PCK) of Portuguese pre-service teachers enrolled in a two-year master's program in Primary Education in Sciences and Mathematics. The main aim was to investigate changes in pre-service primary teachers' PCK concerning interdisciplinarity in science and mathematics following their participation in a lesson study. This presentation highlights the exploratory phase of the study, analyzing PCK prior to the implementation of the lesson study. The research is part of a broader project that aims to understand the dynamics of implementing interdisciplinary activities in Mathematics and Sciences. It involves pre-service primary teachers from two Portuguese higher education institutions, the Polytechnic Institutes of Setúbal and Lisbon, within the framework of lesson study.

METHOD

The participants were the whole class of the teaching master programme 2024/25, 11 pre-service primary teachers (8 females and 3 males, aged 22 to 35 years) enrolled in the courses "Didactics of Sciences", "Didactics of Mathematics" and "Teaching Practice in Primary Education". These are annual compulsory subjects in the second-year curriculum of the master's program in Primary Education (1st to 6th grades) with a specialization in Mathematics and Sciences, of the School of Education of Setúbal, Portugal. Prior to this

program, the pre-service teachers had completed a three-year degree in Basic Education. The Didactics courses in both areas involved the exploration of different strategies for teaching science and mathematics and were used to support the planification of the research lesson, that was implemented during a seven-week internship in a 5th grade class (Teaching Practice).

During the first semester, the students completed a questionnaire to assess their pedagogical content knowledge of interdisciplinarity in science and mathematics, both before and after the implementation of the lesson study. The questionnaire was less structured, word-based and open-ended to capture the specificity of the situation analysed in this study (Cohen, Manion & Morrison, 2007). This research instrument included four open-ended questions, as follows:

- (1) Identify a curricular topic that integrates Mathematics and Sciences and can be approached interdisciplinarily in primary education (Key Stage 2);
- (2) Indicate Mathematics and Sciences content that can be approached interdisciplinarily in the study of the topic you identified. You may use a diagram to illustrate the relationships between the content. (Note: Students were allowed to consult official curriculum documents.)
- (3) Provide examples of one or two interdisciplinary activities you would use to explore the topic, incorporating the previously mentioned content from both subjects. Specify the teaching strategies or methodological approach you would adopt in the classroom.
- (4) If you have already planned or observed an interdisciplinary activity during previous internships or even during your school years as a student, describe the activity in question, highlighting its relevance.

The analysis of these questions involved content analysis, with the definition of categories and subcategories for analysis for each question, which were formed inductively based on data, through an iterative process. Table 1 presents the categories and subcategories defined for the first question in the first application of the questionnaire. The presentation explores the methodological options of content analysis of the whole questionnaire.

Table 1. Categories and subcategories for analysis of the questionnaire first question “Identify a curricular topic that integrates Mathematics and Sciences and can be approached interdisciplinarily in primary education (Key Stage 2)” before lesson study.

Categories	Subcategories
Topic	Specific
	General
Subject	Sciences prevails
	Mathematics prevails
	Both areas
Content or process	Focus on content/concepts
	Focus on process/methodology
	Content and process

The lesson study process was structured in three main phases within a single cycle. In the first phase, during weeks one to four of the seven-week internship, the pre-service teachers worked in groups to define the goals and plan a research lesson centred on an interdisciplinary activity in Mathematics and Sciences, supported by the four higher education teachers, the authors of the study, in Didactics sessions. In the second phase, during weeks five to seven of the internship, one team student taught the research lesson while the other student and one higher education teacher observed and collected data. The third phase, conducted after the internship, involved a group discussion about the planned and implemented lesson and an individual written reflection.

RESULTS AND DISCUSSION

Table 2 presents the results for question 1: *Identify a curricular topic that integrates Mathematics and Sciences and can be approached interdisciplinarily in primary education (Key Stage 2)*, based on the responses of the 11 students, pre-service teachers, who participated in the study. The results seem to show that the students identified either specific or broader themes for integrating sciences and mathematics in an interdisciplinary way. The selected themes reveal a predominance of sciences, followed by those that explicitly connect the two subject areas. Additionally, as anticipated given the nature of the question, there is a clear focus on content in the identified topics.

Table 2. Pre-service teachers’ responses to the questionnaire first question “Identify a curricular topic that integrates Mathematics and Sciences and can be approached interdisciplinarily in primary education (Key Stage 2)” before lesson study.

Categories	Subcategories	Frequencies	Example
Topic	Specific	6	“Calculating the average temperatures of various regions of planet Earth (...) water in a liquid state, favouring life on Earth.” (CF)
	General	5	“Water consumption and conservation” (IM)
Subject	Sciences prevails	6	“Biodiversity” (AM)
	Mathematics prevails	1	“Transform the percentages of water suitable for consumption and not suitable for consumption on the Earth into fractions and decimals” (VB)
	Both areas	4	“«Data» and «Diversity of living beings and their interactions with the environment»” (AS)
Content or process	Focus on content/concepts	8	“Healthy eating” (ASF)
	Focus on process/ methodology	0	n/a
	Content and process	3	“Vegetable consumption in different animals: a statistical study” (MS)

Some of these findings are further supported by the students' responses to the remaining three questions of the questionnaire applied prior to the lesson study. In response to the second question, which asks students to explain the content associated to the selected topic, the results highlight a predominant focus on knowledge to be explored interdisciplinarily, with less emphasis on skills and attitudes. For the third question, which requests an example of an activity, the results continue to indicate a predominance of sciences and that the articulation of mathematics occurs mainly through data processing. These results, that show a limited IPCK, will be discussed in greater detail in the presentation.

The preliminary results indicate that the pre-service teachers generally exhibit a limited perspective on interdisciplinarity in science and mathematics. Connections between science and mathematics are present, however, there is a predominance of uneven connections expressed by using more ideas from one discipline than the other. Few students view interdisciplinarity as a meaningful integration of mathematics and science, when the disciplines interact to support each other, allowing unique learning (Huntley, 1998). Moreover, although students were allowed to consult official curriculum documents, their approach to mathematics and science concepts and processes was not always relevant or appropriate to a 5th grade class.

As part of the project’s development, the pre-service primary teachers participated in a lesson study, a formative process that emphasizes collaborative work in planning, observing, and reflecting on implemented lessons, with a focus on deepening their PCK (Martins et al., 2023). During this process, the students not only planned and explored tasks, but also reflected on their experiences, identifying areas for improvement and

adjustment in their interdisciplinary practices. It is anticipated that their initially limited understanding of interdisciplinarity has evolved into a more comprehensive perspective, one that incorporates the PCK of each discipline and their potential intersections (An, 2017). The analysis of the second questionnaire, conducted after the lesson study, along with the other pre-service teachers' productions, may provide insights into these possible changes, particularly in their IPCK.

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