

Pedagogical and content knowledge in the educational practices of novice mathematics teachers in primary education

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ABSTRACT

This study focuses on novice teachers of basic education with a specialisation in mathematics and their first and important stage of professional insertion. It is widely known that the first years of teaching is a challenging and complex process, where the processes of accompaniment have very little effective space in educational environments in Latin America and in other latitudes, causing uncertainties and tensions to the recent graduate that affects the first educational practices as a new teacher. From a qualitative paradigm and using a case study, the transcripts of interviews and documents were analysed in order to deepen the contextualisation of each participant, with the aim of finding out what didactic difficulties exist in the novice mathematics teacher at primary level. The first results offer an inductive categorisation of difficulties, identifying them as cross-cutting themes in initial teacher training. Furthermore, it is identified that the difficulties are found in the training plans, showing that it is necessary to carry out a permanent monitoring of initial training in order to have better prepared mathematics teachers at primary level.

Keywords: Teacher's knowledge, Professional Insertion, Primary School Mathematics Teacher and Difficulties.

1. INTRODUCTION

Teachers are key to improving quality in education, positioning themselves as transformational agents whose practices focus on the comprehensive education of students (Castillo-Vega et al. 2022). From this context, a global trend has emerged to define or characterise the meaning of "a good teacher" (Levy-Felman, 2018) through the declaration of competence models and teaching standards, which have not been free of criticism, as teacher training does not have the mechanisms to ensure that teachers have acquired the necessary competences to develop in the future workplace, which is manifested through educational practice (Manso and Donaire 2022). Furthermore, the tasks of

optimising good teacher practice must be put into permanent monitoring, collegial dialogue and permanent updates of trends and scientific currents in the field.

The initial training provided by training institutions has developed permanent mechanisms to improve curricular programmes according to the declaration of teacher policies, aiming to strengthen training through pedagogical and disciplinary knowledge, in order to perform professionally in educational contexts (Vaillant and Manso, 2012), allowing novice teachers to approach the work environment. Subsequently, at the beginning of the professional career of "beginning" or "novice" teachers, they are visualised as a teacher facing complexities that are often new and linked to the process of adaptation and accommodation of an educational community; but in addition, this process can be identified as a transition from a trainee teacher to an autonomous professional (Vonk, 1996; Avalos, 2009; Alliaud, 2014; Beca and Boer, 2022), stages that are part of the professional career and the continuous professional development of teachers.

In Chile, trainee teachers in Primary Education are not exclusively trained in the area of mathematics; during their formative years they must acquire general disciplinary and pedagogical knowledge, a situation that has a general tone in Latin America. However, at the end of their training process, mathematics courses and their didactics have an average of four to six subjects, significantly affecting and limiting the mastery of content knowledge. In this respect, the literature indicates that this professional presents certain gaps and that they are reconstructed from their own experience or from their beliefs for teaching (Hernández, 2022). Such limitations in the mathematics teaching process have been perceived as a contributing factor to low student achievement in mathematics (Turner and Rowland, 2010).

It is expected that this professional who is entering teaching for the first time will have a deeper knowledge of the mathematical and pedagogical content of the content, for this, it is interesting

to observe and identify the actions that the professional performs in school contexts. In this sense, and for the purposes of this study, the theoretical model The Knowledge Quartet (KQ) was used to understand and interpret the educational practices that the novice teacher deploys in the classroom, as it allows to interpret and categorise classroom situations and contribute to the improvement of the educational practice of novice teachers of primary education, with mention in mathematics.

On the basis of the ideas set out above, the research proposal interprets the teaching processes carried out by novice teachers in the first semester of entry into the education system in Chile, specifically in Primary Education teachers with a specialisation in mathematics. In the review of the literature, no research has been found in the area, and the literature does not describe the difficulties that new teachers have in pedagogical and didactic aspects in general (Vaillant, 2022) and not in their specific area based on a discipline, in this case, mathematics.

With respect to the difficulties presented by the novice teacher in educational practice, it is of interest to interpret the actions that he/she carries out in the process of teaching mathematics in primary education, considering Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK) (Shulman, 1987), and which is manifested in the novice teacher in the development of mathematics teaching.

2. THEORETICAL FRAMEWORK

The construction of mathematical knowledge in a school context requires interpreting the teaching practice of novice teachers in the teaching action. The Knowledge Quartet (KQ) is a framework for identifying and developing mathematics content knowledge in novice teachers (Turner and Rowland 2010). Based on Shulman's (1987) theoretical framework, it categorises classroom situations that arise in primary mathematics lessons by novice teachers and aims to identify the forms of knowledge as it manifests itself, both in the design and planning process and in teaching. It also draws on discussion and reflection on mathematical content knowledge among teacher educators, mentor teachers and novice teachers.

KQ is a framework that favours observation and mathematics lessons by novice teachers, through the accompaniment of a mentor teacher and teacher trainer, providing discussion on the SMK, providing reflection on the teaching of mathematics and the knowledge that manifests itself in the classroom, which leads to study the relationship with the SMK and PCK. Also, its interest lies in building the necessary knowledge in novice teachers for the teaching of mathematics, addressing those aspects that emerged from classroom observation.

KQ is made up of four dimensions: Foundation, Transformation, Connection and Contingency, which between them, allow for a review of mathematics teaching after classroom observation.

- 1) Foundation. It is based on the foundations of the theoretical training and beliefs of the teacher, it is about the acquired knowledge;
- 2) Transformation. This refers to the ways and context of how knowledge is put into practice in the preparation

and development of teaching, focusing on knowledge in action;

- 3) Connection. This is the act of making connections between the various parts of the mathematical content, i.e. it is the integrity of the mathematical content that is constructed in the teacher's mind, being largely the knowledge and structural connections within mathematics itself; and
- 4) Contingency. It manifests itself in those unexpected situations or events that occur in the classroom that are not planned.

3. METHODOLOGY

Due to the characteristics of the problem and from an interpretative paradigm, a qualitative method was used, since the purpose was to observe and contribute to the novice teacher in his educational practice. The research design used will be of the Case Study type (Stake, 2007), since it allowed us to observe and understand the new teacher in his educational practice, and thus deepen in the experiences of the teacher and interpret the SMK and PCK that is manifested in the design of the class lessons and in the educational practice.

The participants were two junior teachers, graduates of the same university and practising within their first year of graduation. Both participants have a half-day job at their new institutions, participating as part of the mathematics department of each institution.

The data collection was based on semi-structured interviews and documentation that allows a deep contextualisation in each of the institutions where the participants work. These documents are the internal regulations, the Institutional Strategic Plan and the mission and vision, all the context information was extracted from the website of the institutions, as it is public information. The interviews were carried out individually, compiling the audios of each one of them, with a duration between 40 and 60 minutes and focused mainly on the obstacles and difficulties that the new teachers experienced when they entered an educational institution, as well as finding out what difficulties persist in their teaching practice and their integration into the educational community. The length is given that initial dialogues are proposed so that the interviewee gains confidence in the ideas and answers, so that in a second stage of each interview the central questions can be addressed directly. Subsequently, the recordings were fully transcribed and analysed from an interpretative level, each of the ideas that emerged during the interview, with the aim of identifying the types of problems encountered in their teaching practice.

The analysis was conducted via the problems of teacher insertion, determining an inductive strategy in the typology of problems, so that the analyses can freely identify the problems that arise. After an initial review, we identified the coincidences that appeared for each participant, on the understanding that both had the same initial training, in the same institution. Then, the names of the emerging categories and subcategories were reviewed, which were validated with a researcher other than the one who initially analysed them. After identifying a coincidence of more than 80%, a meeting was held to reach agreements between the remaining 20%, which provided an internal validation environment for the categories identified.

4. RESULTS

From the intrinsic case study, it allowed us to interpret and understand the problems expressed by the novice teachers, as well as to develop conceptual categories about the mathematical knowledge in use, belonging to the KQ theoretical model, identified as: foundation, transformation, connection and contingency.

Table 1 shows the categories to be used for the development of this research, which is still in progress. The collection of information will be triangulated from the recordings of classes and meetings with the new teacher and will be contrasted with the class planning and transcribed in detail -or the use of software such as Atlas. Ti for the analysis of videos and audios-, to raise categories by means of the previously mentioned variables of the KQ, which will allow to identify, to understand and to interpret SMK and PCK that the novice teachers use in their educational practice for the teaching process.

Foundation	The meanings and descriptions of relevant mathematical concepts and the relationships between them.
	The ontological status and aims for teaching.
	Identifying errors
	Manifest knowledge of the subject matter.
	Theoretical basis of pedagogy.
Transformation	Teaching procedures: methodologies or strategies
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	Choice of examples for teaching
	Model and solve problems
	Use of mathematical language
Connection	It unifies the concepts discussed and extracts coherence between meanings and representations.
	Anticipation of task complexity
	Decision on the sequence of mathematical concepts to be covered
	Recognition of conceptual appropriateness related to the cognitive demands of concepts or procedures, paying attention to the sequence of content.
Contingency	Responding to students' ideas
	Difficulties encountered in the teaching and learning process
	Unforeseen situations in the development of the class by both the teacher and the student.

5. DISCUSSION

The categories identified here are an interesting insight into the difficulties encountered by novice mathematics teachers. What is usual in this type of study is to offer a general level of analysis, which does not specify what happens with the problems of teaching mathematics, which is why the first findings identified are of particular interest (Reich, 2020; Hernández, 2022; Vaillant, 2016).

Regarding the findings, it is very interesting to know that some subcategories present special attention in schools that train mathematics teachers at primary level, and even so, they are clearly identified as difficulties present in the professional insertion of these teachers. Such a situation invites to define a permanent monitoring work on how it is possible to better meet the educational needs of society, and how curricular innovations take a major role in the direct attention to such difficulties.

Finally, we consider that this study should be the beginning of many other questions to be addressed for the professional insertion of teachers, especially at the primary level where the teacher has a generalist stamp in his or her professional practice. With regard to didactic difficulties, it is incipient to identify as action environments for curricular readjustments in the area of Mathematics Education, which should be a permanent concern of all schools that train teachers, since not only are there degrees of ethical responsibility in the initial training, but also in the insertion. This issue has been widely studied in different latitudes (Colazzo-Duarte, 2021), finding alternatives with varying degrees of success in many areas. Undoubtedly, there is much more to explore, which should be a permanent challenge for mathematics teacher education.

6. CONCLUSIONS

The categories and subcategories identified in the present study provide a source of information about the possible environments and focuses of development in initial teacher training for primary school teachers. This can directly contribute to the processes of accompaniment and professional practice, providing topics of sufficient interest for treatment in the course of training.

The four categories identified express a degree of transversality in their treatment, i.e. they do not have an encapsulated characterisation of knowledge, but require in-depth treatment in the different subjects of mathematics and mathematics education that are considered in initial training. By way of example, the subcategories: identifying errors, modelling and solving problems, anticipating the complexity of the task, difficulties that arise in the teaching and learning process, with subcategories that should have a cross-cutting treatment in the different thematic axes of the curriculum. This situation should invite a tone of attention to how initial training is being defined.

Some of the resulting categories could be assumed to have been expected. For example, all the subcategories of the Contingency category are possible to assume, since the teaching practice itself and the work with different people with the mechanisms to enrich the multiple responses that arise from the students, or to be attentive to the different unforeseen situations, or even the various difficulties arising from the teaching and learning processes. Such ideas should lead to more and better accompaniment programmes that can deal with this type of situation in a structural manner, as is the case in other parts of the world.

7. REFERENCES

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