THE MTE: MANAGING THE PROFESSIONAL EMPOWERMENT OF PROSPECTIVE PRIMARY TEACHERS

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The knowledge and practices of primary mathematics teacher educators in the period of initial training have the same impact on prospective primary teachers as teachers' knowledge does on their students' learning. The aim of this study is to contribute to characterising educators' knowledge, particularly with respect to developing their students' abilities and professional identity. Based on the observation of a training session and an interview, we recorded instances of a primary teacher educator's knowledge, which we then analysed. The results indicate that not only the construction of professional knowledge, but also the development of teaching abilities and the sense of belonging to a community of teaching practices, become key to the process of professional empowerment of the prospective primary teachers.

THEORETICAL BACKGROUND

Mathematics teacher educators' (MTEs) knowledge is one of the major challenges in mathematics education research today (Chapman, 2021). Understanding and characterising MTEs' knowledge means recognising their role as agents of change in the learning of prospective primary teachers (PPTs), in the same way as had traditionally been recognised in terms of mathematics teachers and their students (Jaworski, 2008).

Research into MTEs' knowledge is based on, at least, mathematics teachers' knowledge (MTK) and knowledge of mathematics teachers' education (KMTed) (Chapman, 2021). MTEs' knowledge should also contemplate the primary teacher's knowledge as part of the content to be imparted/constructed in the course of the training. Consequently, many approaches to educators' knowledge have been couched as extensions to the teacher's knowledge (Castro-Superfine, *et al.*, 2020; Perks & Prestage, 2008; Zaslavsky & Leikin, 2004), adapted to the primary training context.

Likewise, teacher educator knowledge in the domain of primary mathematics should consider aspect related to how to teach teachers' knowledge (KMTed). In this regard, the work of Chick and Beswick (2018) and their characterisation of the pedagogical content knowledge of primary teacher educators suggests that it is a question of the educator's meta-knowledge of how to teach content knowledge for teaching mathematics.

Our views on the knowledge of MTEs are consistent with many previous studies. On the one hand, we consider that there are many points of contact between the educator's knowledge and the teacher's knowledge, although there are areas of divergence, too. The differences revolve around the depth of understanding of mathematical content,

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and the connections between the mathematical content and pedagogical content knowledge which the educator might have (Escudero-Ávila, Montes & Contreras, 2021).

Nevertheless, bearing in mind the observations of Ponte (2012) regarding the structuring of primary teacher training, the educator's knowledge should also include elements of knowledge of the teaching as a profession, professional practices, and professional identity, along with such knowledge as will allow them to help the PPTs gain access to these elements. Likewise, these areas of knowledge should be combined at the two levels at which the educator discourse is focused – that of the initial training classroom and the PPTs, and that of the future mathematics classroom and the students (Jaworski & Huang, 2014). Although the educator's knowledge should be understood as *multidimensional*, *complex* and *indivisible* (Escudero-Ávila *et al*., 2021), the analytical advantages of establishing different categories of knowledge leads us to consider the structure and content of the MTSK model (Carrillo *et al.*, 2018) as the inspiration for the conceptualisation of the educator's knowledge.

Our study aims to contribute to the characterisation of the educator's knowledge, and to explore the connections between the elements of this knowledge, foregrounding how this promotes the development of PPTs' abilities and teaching identity during the initial training. To do so, we focus on analysing which aspects of the MTEs' knowledge enables them to manage sessions of primary teachers' initial training which promotes that the PPTs learn how to act as teachers, and to recognise themselves within the teaching community. In the next section, we describe the methodological aspects of the study.

ANALYTICAL APPROACH

The study took the form of a case study (Bassey, 1999), in which an expert informant was selected (a mathematics education researcher working in the field of teachers' knowledge and professional development, with more than thirty years as an educator, whose work is widely respected within the academic community), henceforth referred to as Lucas. Several distinct training sessions were observed and video-recorded, and the foundations of these sessions were then discussed with him.

The excerpts discussed in this study correspond to the evidence of knowledge identified in the course of a session in which the definition of polygon was constructed with the PPTs, as part of the course content on the methodology of geometry in the Degree in Primary Education at a Spanish university. Once the class extracts had been selected, we identified points providing evidence of different kinds of knowledge according to the method of content analysis (Krippendorff, 1980). The accumulation of these focal points developed our understanding of the educator's knowledge, and each was matched against the analytical structure by Escudero-Ávila *et al*. (2021). The process of discussing these episodes by a group of experts, and contrasting the evidence obtained according to different data gathering tools (Baxter y Lederman, 2001) enabled us to triangulate and validate the various elements of the educator's knowledge. This

in turn helped us to understand how Lucas managed the learning of different professional practices related to task planning, and how he promoted certain values which constitute a teaching profile, and supported the development of the PPTs' professional identity.

ANALYSIS AND DISCUSSION

Lucas presented this session to the PPTs a class in which the main objective was tackling the mathematical practice of defining, specifically in this case the construction of the definition of a polygon. The session was structured around a set of geometric shapes which formed the basis of a discussion about the mathematical elements which make up the definition of a polygon (Figure 1).

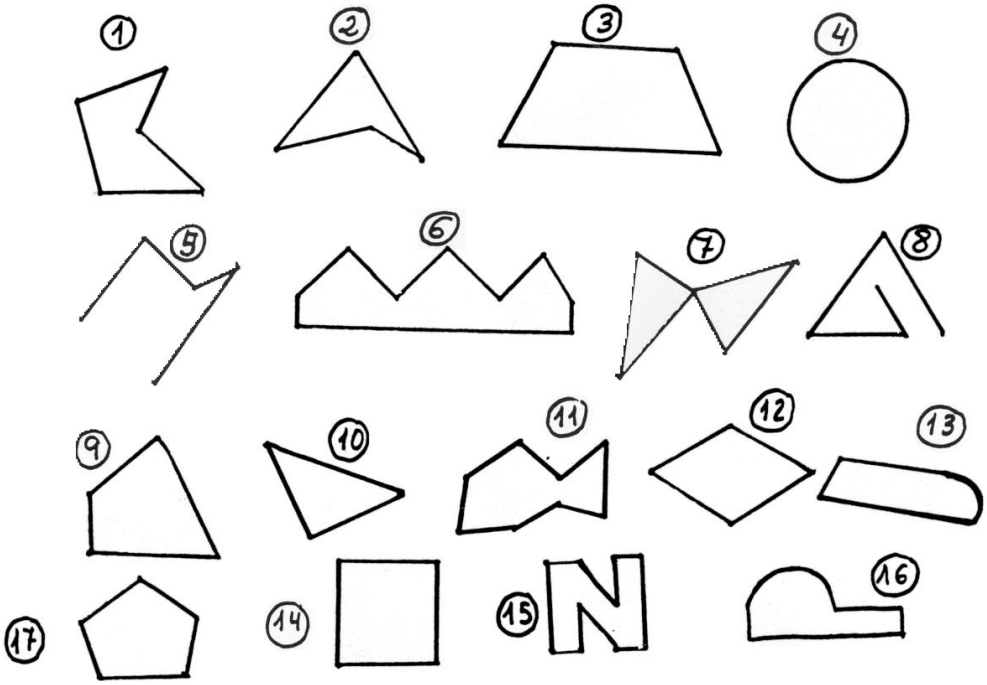

Figure 1: A selection of examples for constructing the definition of a polygon.

Taking the perspective on exemplification offered by Watson and Chick (2011), Lucas' handling of the selection of examples provides indications of his mathematical knowledge regarding the definition of polygons and the practice of defining, especially in the way he guides discussion of the necessary conditions and leads his students to inductively construct a definition of a polygon.

Lucas presents the construction of mathematically satisfactory definitions as a social activity, that is, as a collaborative endeavour. The approach reflects his beliefs about what mathematics is, which, although not the direct focus of this study, can be transmitted over the course of the initial training programme as a source for configuring the students' teaching profile:

> Lucas: Let's see if we can remember. What are the arguments underlying what we've agreed on so far? What might be revealed by including or excluding the circle in the set of polygons? That's one of the things we're going to

> look at today. If we decide it's a polygon, what consequences follow on from that? ¿OK?
>
> […]
>
> What else do we need to think about? Is there just one way of defining a polygon? Is there a correct way? Or are there various possibilities?

The discussion about the consequences of including certain shapes inn the set of polygons further illustrates Lucas' understanding of the interdependence of the mathematical results which they are hierarchically constructing. The fact that Lucas highlights these mathematical relationships not only illustrates his conceptualisation of mathematics as a connective network linking together concepts, procedures and practices, but also represents an opportunity to empower the PPTs to become actively engaged with mathematical knowledge. The ability to recognise these relationships and to be able to construct new ones by changing the underlying premises, is indicative of deep mathematical knowledge. It is this kind of knowledge, in particular with respect to the knowledge of topics (KoT) and knowledge of practices in mathematics (KPM) subdomains (Carrillo, *et al*., 2018), which mark the difference here between the primary teacher educator and primary education teachers, as other episodes across the full study also suggest.

Showing awareness that the PPTs are immersed in a process of reformulating their mathematical knowledge during the course, Lucas draws on exemplification and analysis of geometric definitions in order to lay the foundations of this new way of understanding mathematical content. Through the principle of isomorphism (Ponte & Chapman, 2008) and the premises of modelling (Rojas, *et al.*, 2021), by which the teaching they receive in their initial training serves as a model for their own teaching when they enter the profession, the PPTs can transform their experience into content for their primary education training.

Lucas' discourse also shows evidence of his knowledge of how to teach content related to planning activities for classroom use, bridging between the context of initial training and that of primary teaching (Jaworski & Huang, 2014)

> Lucas: Let's take a moment to reflect now about the wealth, when it comes to making distinctions, the wealth that each step we took in the elimination process could give rise, yeah? Thinking about how we now understand those steps. And how the act of defining, agreeing properties together, leads us to a shared definition of a polygon, as opposed to a definition that's imposed, where we don't understand why those particular criteria have been imposed. And it's just the same when you come to teach it, because your pupils can also go through this process, which is such a richer experience.

Lucas makes it very clear that the PPTs are perfectly capable of planning primary lessons which are fully consistent with what they have experienced themselves in their initial training. This excerpt brings to the fore how Lucas articulates various elements

of his knowledge in order to mould the task, which at the same time serves as a model for teaching in the primary context. What he does can be interpreted as putting into effect his knowledge of teaching pedagogical knowledge for the teaching of mathematics.

In the extract below, when some of the PPTs encounter difficulties with the task, Lucas makes reference to different approaches to defining a polygon. In doing so, he demonstrates his knowledge of traditional modes of teaching mathematical concepts, where in the past deductive methods predominated:

> Student: Me, at least the way I see it, if we can't compare it with anything, if we're not sure about what a polygon is, then how can we say if it's a polygon or not?
>
> Lucas: Well, you're negating the main thing. What you're saying is: "Unless I have a definition, how can I know what a polygon is?" Well, OK, let me turn that back on you, because what you're essentially saying is that the only way to define something is to go from the general to the particular. And I want to question that. Maybe it's because that's what you're used to. I want to know if it is possible, based on different particular situations, to try and construct a general concept.

The activity of constructing the definition of a polygon, and the considerations of what to take into account when teaching the topic, is brought to a close by Lucas' reflections on the teaching materials used at this level, specifically the textbooks. His comments illuminate his perspective on the teacher's professional identity, locating them as an expert in the teaching of mathematics, capacitated to make analytically based decisions on the material they use.

> Lucas: What would be nice now would be to have a look at the textbooks, which is the third part of the activity, and see if the definition of a polygon which they give in the textbooks is the same as ours, and see if our process has been a richer or less rich experience than what the book offers, which almost certainly the complete opposite. So I suggest that's what you do. We can definitely find it in the books for third year primary. I recommend you have a look at how polygons are introduced, how they introduce them.

The work on defining a polygon was complemented by the video recording of a primary lesson in which the teacher carried out an activity similar to that the PPTs had experienced. As a follow-up, they were asked to think about which aspects of the teacher's performance had stood out, what suggestions they might make for areas of improvement, how effective they considered the examples used, and what interventions or responses by the pupils had struck them.

The design and execution of this kind of activity by the educator as part of the initial training course illustrate his knowledge of the professional practice of planning tasks for teacher education which become the principal focus of the session. The teacher educator leads a discussion phase covering different elements of professional

knowledge, but its essential function is to provide a model of how the PPTs might proceed in their own future classes, which they then subsequently discuss. The discussion of the examples deployed by the teacher in the video places the focus on the role of exemplification as a teaching tool, in particular the choice of examples, their degree of transparency, and the educational potential of the example space. In this regard, the educational practice considered in this phase provided evidence of another area of the educator's knowledge.

CONCLUSIONS

The conclusions to be drawn from this study underline the importance of the interconnections between the trainer's knowledge of primary education teaching practices, the means of transmitting these to the PPTs and professional empowerment in education. The teaching of such educational practices as task design and exemplification represents one of the distinguishing elements of initial primary training with respect to other university domains involving the teaching of mathematical content. Recognising the specificity of content involved in primary teacher training, and the importance of the educator's knowledge in developing this, represents an advance in improving the teaching and learning of mathematics at various educational levels. It is here where the chief contribution of this study lies, and in this regard it fits alongside the developments in characterising educators' knowledge proposed by Escudero-Ávila *et al*. (2021).

The knowledge required by MTEs to be able to manage the learning of these practices following the practices of isomorphism (Ponte & Chapman, 2008) or modelling (Rojas, *et al.*, 2021), can be interpreted from the perspective of practical wisdom described by Perks and Prestage (2008), but requires an exhaustive revision so as to understand the different ways MTEs deliver the training content to the PPTs. Progress along these lines would see an improvement in programmes for training educators. Analysis of video-recorded lesson, such as that described in this study, and roleplaying activities in the training course, which we also saw in or wider study, amplify the modes available to MTEs for teaching to teach mathematics, and rest on both knowledge of training content and pedagogical content knowledge for training.

The development of teachers' professional identity can take place in parallel with work on professional practices in initial training course. The inclusion of content dealing with the day to day concerns of teachers directs the PPTs' awareness towards their professional future, and encourages them to see themselves as teachers rather than students. Nevertheless, occasions when the educator expresses their knowledge of professional values or attitudes, and beliefs about mathematics and its teaching and learning, confirm the presence of content related to the configuration of teachers' professional identity in the initial training course. Further studies are needed in this vein to help us systematically identify the signals that recurrently appear in studies of educators' knowledge. The configuration of teachers' professional identity and the

development of professional profiles constitute one of the major milestones in the initial training of primary teachers.

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