TEACHERS' META-DIDACTICAL PRAXEOLOGIES IN TECHNOLOGY-SUPPORTED FORMATIVE ASSESSMENT: A PROFESSIONAL DEVELOPMENT STUDY

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The study investigates how lower secondary mathematics teachers engage with technology-supported formative assessment within a professional development program, adopting the Meta-Didactical Transposition framework as the main theoretical lens. The program was inspired by the FaSMEd Toolkit and encouraged teachers to adapt and redesign proposed activities. Data from lesson plans, reflective questionnaires, and professional development meetings were analysed in terms of teachers' meta-didactical praxeologies. The findings show that teachers reinterpreted the Toolkit through shared and evolving praxeologies, aligning technology use with formative purposes.

INTRODUCTION

Formative assessment (FA) is widely recognized as a powerful approach to support students' learning and to inform instructional decision-making (Black & Wiliam, 2009). However, the implementation of FA in everyday classroom practice remains challenging for many teachers (Schildkamp et al., 2020). From a Meta-Didactical Transposition (MDT) perspective (Arzarello et al., 2014), these challenges can be interpreted as the result of complex processes through which assessment-related knowledge and practices are transformed, reinterpreted, and internalized within teacher education contexts. In this view, FA is a system of practices and values that undergoes meta-didactical transformations when teachers engage with resources, theoretical principles, and professional development (PD) settings.

This study explores the design and analysis of a PD program for lower secondary school mathematics teachers inspired by the resources developed within the Formative Assessment in Science and Mathematics Education (FaSMEd) project (Aldon et al., 2017; Cusi et al., 2017). The PD program encouraged teachers to adapt and transform existing materials in relation to their classroom contexts. The focus of the current study is therefore on the meta-didactical processes underlying teachers' planning and implementation of technology-supported FA activities. Within the MDT framework, these processes are analysed in terms of teachers' meta-didactical praxis and logos.

BACKGROUND

Formative assessment is defined as a teaching approach in which evidence about student achievement is used to inform instructional decisions that are better founded

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than those taken in the absence of such evidence (Black & Wiliam, 2009). Within this approach, feedback, classroom discussion, and students' active participation play a central role in supporting learning. Wiliam and Thompson (2008) identified five key strategies for FA: "(1) clarifying and sharing learning intentions and criteria for success; (2) engineering effective classroom discussions and tasks that elicit evidence of learning; (3) providing feedback that moves learners forward; (4) activating students as instructional resources for one another; (5) activating students as the owners of their own learning" (p. 63). These strategies emphasize the use of information about students' learning to adapt teaching and support learning processes.

The European project *Formative Assessment in Science and Mathematics Education* (FaSMEd) aimed to improve students' achievement through technology-supported FA. Across the project, researchers investigated how digital tools could support FA strategies, leading to the identification of three key functionalities of technology: sending and displaying, processing and analysing, and providing an interactive environment (Aldon et al., 2017). Within the Italian strand of the project, particular attention was given to mathematical discussion as a privileged context for FA. Connected classroom technologies were used to support classroom interactions, including the collection and analysis of students' responses and the orchestration of whole-class discussions. Three types of digital worksheets—problem, helping, and poll worksheets—were developed to foster argumentation, reflection, and students' metacognition (Cusi et al., 2017). One of the main outcomes of the project was the FaSMEd Toolkit (https://microsites.ncl.ac.uk/fasmedtoolkit/), which includes conceptual frameworks, lesson plans, and narrative accounts of classroom practices. Despite its potential, limited empirical evidence is available on how teachers interpret, adapt, and enact the Toolkit in PD and classroom contexts. This study builds on the Italian experience of FaSMEd to analyze a PD program inspired by the Italian part of the Toolkit, focusing on teachers' engagement with and transformation of the proposed resources.

THEORETICAL APPROACH

The study is grounded in two complementary frameworks: the Reflective and Communal clusters suggested by Shulman and Shulman (2004) for professional development and the MDT framework (Arzarello et al., 2014). While the former informs the design of the PD program, the latter constitutes the main analytical framework of the study.

The reflective and communal learning environment highlights the role of reflection and collaboration in teachers' professional learning (Shulman & Shulman, 2004). Reflection on practice, supported by discussion with peers and researchers, can foster teachers' awareness of their instructional choices and support the development of new professional knowledge. The MDT framework is rooted in Chevallard's Anthropological Theory of the Didactic and was specifically developed to investigate teacher education processes (Arzarello et al., 2014; Robutti, 2020). Central to MDT is

the notion of praxeology, according to which human activity can be described through the interrelation of praxis (namely, tasks and techniques) and logos, the latter comprising technology and theory. Within the MDT, a distinction is made between didactical praxeologies, which concern classroom-level teaching practices, and meta-didactical praxeologies, which pertain to the reflective, collaborative, and design activities carried out by teachers and researchers in PD contexts. Meta-didactical praxeologies are therefore particularly relevant for investigating how teachers conceptualize, justify, and transform instructional practices when engaging with existing resources.

A key process within the MDT is internalization, defined as the transformation of external components—introduced through PD or collaboration—into internal elements of teachers' praxeologies (Cusi et al., 2022). Internalization is not conceived as a linear or automatic process, but as the outcome of meta-didactical work involving adaptation, justification, and reflection. In this study, teachers' engagement with the FaSMEd Toolkit and their design and implementation of technology-supported FA activities are interpreted as components of their meta-didactical praxis. Teachers' justifications and reflections, as emerging from lesson plans, discussions, and interviews, are analyzed as elements of the corresponding meta-didactical logos. The MDT framework thus provides the main theoretical lens for examining how FA practices are transformed through PD. Adopting the MDT framework, this study investigates how teachers' engagement with the FaSMEd Toolkit gives rise to specific forms of meta-didactical praxis and logos related to technology use during a professional development program.

METHODS

Study design and participants

This research was carried out as part of a PD program. A sequence of PD meetings was designed for a group of teachers who were already engaged in continuous PD with a particular emphasis on mathematical argumentation. This emphasis was strongly aligned with FA, as argumentative practices play a key role in eliciting, interpreting, and using evidence of students' learning during classroom interactions (Cusi et al., 2017). Teachers and researchers met in a hybrid format approximately twice per month, from October 2024 to June 2025.

The PD program was structured cyclically and comprised four interconnected micro-cycles. The first formative assessment cycle (FAC1) aimed to familiarise teachers with FA strategies, argumentation, and the principles of the FaSMEd Toolkit. In FAC2, the sessions primarily focused on activities drawn from the FaSMEd Toolkit. During FAC3, teachers selected a FaSMEd activity and designed a corresponding lesson plan, while FAC4 involved the implementation of these plans in classroom settings. Throughout the PD meetings, teachers engaged in reflective discussions on the activities, their lesson designs, and classroom implementations, sharing their intentions, experiences, and perceived constraints with other teachers.

The participants were six mathematics teachers with varied teaching experience, ranging from a first-year teacher to teachers with more than 30 years of practice. Their familiarity with the FaSMEd project also differed: one teacher (Matilde) had previously participated in the FaSMEd project, two teachers (Flavia and Maria) were familiar with the activities, and three (Caterina, Maura, Petra) had no prior experience with the FaSMEd. Teachers also differed in their length of involvement in the PD community, ranging from newly joined members to long-term participants with over ten years of engagement.

Data collection and analysis

Multiple data sources were employed to support triangulation and to develop a comprehensive account of the research process. The data set comprised four reflective questionnaires, video-recorded PD meetings, and teachers' lesson plans. The questionnaires captured teachers' educational backgrounds, prior experience with argumentation, FA and technology, familiarity with the FaSMEd project, and self-reported adaptations and implementations of the activities. During the PD meetings, teachers shared their lesson plans with revised versions of the FaSMEd activities, reflected on their classroom implementations and engaged in questioning and feedback directed at one another. A thematic analysis approach (Braun & Clarke, 2006), guided by the MDT framework, was used to identify emerging techniques across participants, and the corresponding professional reasoning (logos), for the task *planning and implementing technology-supported FA activity with an argumentative component*. Analysis followed an iterative process. First, questionnaire responses, lesson plans, and PD meeting data were organized to develop an overview of each teacher's practices. An analysis table was constructed for each teacher, integrating excerpts from these data sources to trace how argumentation, FA, classroom discussions, and technology were planned, implemented, and justified within the FaSMEd activities. These tables functioned as analytical tools for identifying patterns and variations in teachers' praxeologies. With the help of this table, codes were iteratively refined and grouped into elements of praxis (recurring techniques) and logos (justifications and theoretical references), in line with the MDT framework. The findings were synthesized in Table 1, which linked techniques and logos with FA strategies (Wiliam & Thompson, 2008) and the functionalities of technology according to the FaSMEd approach (Cusi et al. 2017), allowing the formative purposes and technological implementation of teachers' practices to be systematically mapped.

FINDINGS

The techniques reported in this section were not only repeatedly planned and implemented by the teachers, but also became central objects of collective reflection during the PD meetings, illustrating how the externally proposed FaSMEd Toolkit was progressively internalized and adapted to teachers' classroom contexts. As shown in Table 1, three shared techniques for planning and implementing technology-supported FA activities were identified.

Table 1: Shared Meta-Didactical Praxeologies related to technology use in technology-supported FA activities

Techniques	Logos	FA	Functionality of Technology
Use of Google Classroom and Google Forms to send worksheets and collect students' responses	It is important to promote students' involvement and focus on the process (Flavia, Maura)	Eliciting evidence of students' learning (Strategy 2)	Technology for sending
	It is important to collect students' responses to prepare for class discussion (Caterina, Maura)	Engineering effective classroom discussion (Strategy 2)	
Use of the Digital Board/Interactive white board to display students' responses	It is important to promote sharing and comparing students' own answers with their peers' answers (Caterina, Flavia, Maura, Matilde)	Engineering effective classroom discussion (Strategy 2) Activating students as an instructional resource for one another (Strategy 4)	Technology for displaying
Use of Padlet and Google Classroom at the end of the class, asking each student to write a report of the class discussion/to solve additional tasks and to comment on a peer's response	It is important to check students' understanding and promote peer assessment (Matilde , Maura)	Eliciting evidence of students' learning (Strategy 2) Activating students as the instructional resources for one another (Strategy 4) Activating students as owners of their own learning (Strategy 5)	Technology for sending and displaying

Teachers frequently integrated digital tools such as Padlet, Google Classroom, Google Forms, and Digital Boards into their instructional design. A prominent technique was the use of Google Classroom and Google Forms in ways coherent with the FaSMEd Toolkit, to send worksheets and collect students' responses. This technique was underpinned by logos emphasizing student involvement and attention to learning

processes. As Maura explained, "I use Google Suite tools because it makes the exchange of ideas very fast and allows everyone to express their opinion, even pupils who are reluctant to do so." In addition, teachers highlighted the value of collecting students' responses in advance to support classroom discussion. Caterina and Maura noted that having access to students' work beforehand enabled them to plan a more focused discussion, while Flavia emphasized that "at the end of each session, I will set aside some time for class discussion based on a preliminary analysis of their work submitted via Google Classroom." Therefore, Google Classroom and Google Forms were used for eliciting evidence of students' learning and engineering effective classroom discussions (FA Strategy 2).

Another shared technique consistent with the FaSMEd Toolkit was the use of digital or interactive whiteboards to display students' responses. The associated logos stressed the importance of sharing and comparing ideas across the classroom. As Matilde stated,

> I would ensure all group answers are noted on the digital board and in students' notebooks. This would help facilitate comparison and discussion of different conclusions.

Here, the digital board functioned as a formative tool to structure whole-class discussion and promote peer assessment (FA Strategies 2 and 4), rather than merely as a display technology.

New technology-related techniques were also proposed by Maura and Matilde, who introduced additional tasks at the end of activities or asked students write a discussion report (via Padlet or Google Classroom) to check students' understanding before moving forward. Both teachers highlighted that the additional questions served to consolidate learning and ensure that all students had grasped the core ideas of the activity. Maura and Matilde also employed technology to promote peer assessment, for example, by sharing students' responses to the additional tasks or discussion reports with the whole class. To illustrate, Matilde used Padlet to collect brief student reports summarizing classroom discussions and invited students to compare their work with that of a peer and provide written comments. She emphasized that "commenting on, correcting, or saying what you think of a classmate's argument … works quite well, it's a form of assessment after the class discussion, so also a bit like a peer assessment." She further underlined its role in "self-correction" and in "having a better view of each student's journey." That means technology should not serve as an end in itself, but rather support formative feedback and self-reflection through peer interaction. This illustrates a logos centered on making students' thinking visible, encouraging peer and self-assessment (FA Strategy 2, 4, and 5).

DISCUSSION AND CONCLUSION

This study examined how teachers participating in a PD program engaged with the FaSMEd Toolkit and how technology-related aspects of their meta-didactical praxeologies developed through this engagement. The findings indicated that while several teacher practices were consistent with the FaSMEd Toolkit, participants also

introduced new techniques, such as using Padlet and Google Classroom for peer assessment and Google Classroom or Google Forms for distributing materials and collecting students' responses. Although these practices correspond to the technological functionalities outlined in the FaSMEd project (Cusi et al., 2017), they extend them by opening additional spaces for peer- and self-assessment. This suggests that the Toolkit functioned as a flexible resource rather than a set of practices to be transferred directly, as teachers reinterpreted it in relation to their own praxeologies and classroom contexts. Across both shared and individual practices, teachers' logos were aligned with key FA strategies, including eliciting evidence of learning, supporting classroom discussion, and promoting peer and self-assessment. Despite differences in the enacted techniques, teachers consistently conceptualised FA as a process-oriented practice aimed at making students' thinking visible and using it as a resource for learning. From the MDT perspective, these findings highlight internalisation as a dynamic process shaped by the interaction between logos, praxis, and contextual conditions, rather than the adoption of predefined techniques.

Differences in internalisation were particularly evident across technological functionalities. While some techniques, such as the use of digital boards, appeared to be readily internalized, others promoted within the FaSMEd Toolkit, such as digital polls, were not taken up. This absence can be partly attributed to contextual constraints (Yan et al., 2021) as well as to teachers' prior experiences with specific tools. Teachers with direct experience of certain functionalities were more likely to recognize their pedagogical potential, even when choosing not to use them (like Matilde, who already had the experience of the FaSMed project), whereas those without such experience did not consider them as viable options. This finding underscores the importance of hands-on engagement in supporting teachers' internalization of new practices, consistent with research emphasising practice-based PD (Grossman et al., 2009).

Finally, the findings point to important implications for the design of PD programs. Toolkit-based PD should be accompanied by opportunities for teachers to experiment with, adapt, and justify practices in authentic classroom settings. Moreover, the communal dimension of the PD program supported collective reflection (Shulman & Shulman, 2004) and the articulation of shared praxeologies, reinforcing the role of collaborative professional learning in sustaining technology-supported FA practices.

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