Supporting Transitions in Mathematics: Initial Design Principles for Teacher Professional Learning

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This study presents initial design principles for a programme of professional learning for teachers focussed on supporting their student's transition from primary to post-primary mathematics. The three key principles proposed to support the design of this programme are: (1) Facilitating primary and post-primary teachers to collaborate as part of a professional learning community; (2) Providing opportunities for teachers to inquire into their own practice through Practitioner Inquiry; (3) Supporting teachers in co-designing rich mathematical tasks that can support and develop students' mathematical achievement.

Introduction

Teachers' Mathematical Knowledge for Teaching (MKT) (Ball et al., 2008) can have an effect on students' experiences and achievement in mathematics. Knowledge of the mathematical horizon (a teacher's awareness of how mathematics is connected over the entire curriculum (Ball et al., 2008)) is one domain of MKT that can be extremely important at the transition between primary and post-primary school.

Transitions in education can provide several challenges for both students and teachers (Anderson et al., 2000; Hopwood et al., 2016). These challenges can be particularly prevalent in mathematics, as from the age of 10 upwards, students experience curricula in new educational environments, including experiencing with subject specialist teachers for the first time in the transition from primary to post-primary level. A wide range of factors that influence transitions in mathematics have been reported and these can affect both students' and teachers' experiences (the other papers in this symposium outline these factors in more detail).

This study proposes the initial design principles for the development of a programme of professional learning to support teachers of mathematics (primary and post-primary) focusing on the transition from primary to post-primary school. An Educational Design Research (EDR) approach is used to support both students and teachers across transitions in mathematics. This study will inform the initial design principles of the Erasmus+ funded Supporting Transitions Across Mathematics and Physics Education project (STAMPEd).

Design Principles for Teacher Professional Learning

Educational Design Research (EDR) addresses educational problems in real world settings and there are several descriptions or definitions of what is EDR. Plomp (2013) synthesises and describes EDR as

> "...the systematic study of designing, developing and evaluating educational interventions as solutions for complex problems in educational practice, which also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them" (p.11)

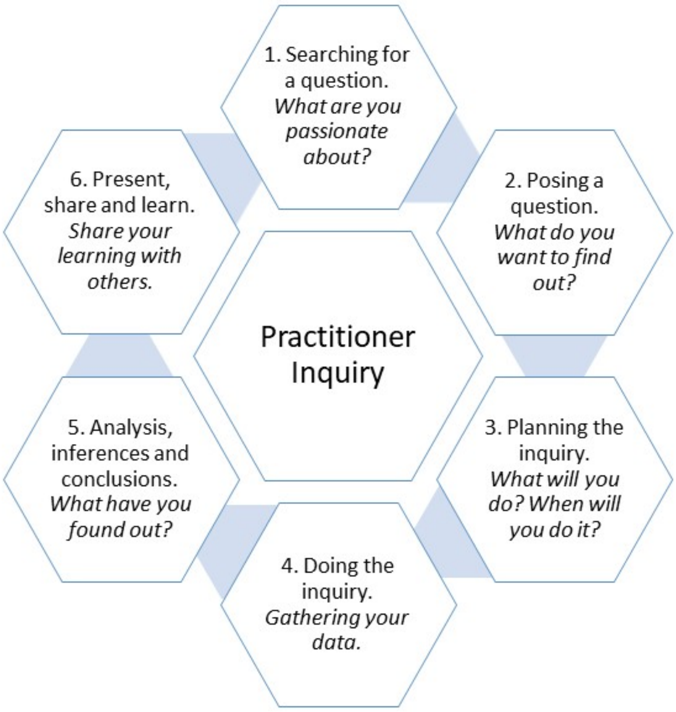
Lovatt et al. (2020) describe how studies that use an EDR approach develop interventions through continuous cycles of design, implementation and refinement, allowing researchers to reflect on the process with intention of identifying design principles. These design principles shape the development and implementation of the intervention, and can inform future design research studies. Their study designed an EDR framework that facilitated teachers working as a professional learning community to reflect and inquire into their own practice of using inquiry based learning in the science classroom (Lovatt et al., 2020). In this study, we use an EDR approach to propose initial design principles for a programme to facilitate teachers working as a professional learning community. The teachers will inquire into their own practice and collaborate to design rich tasks in mathematics that support student learning in the transition from primary to post-primary school.

Practitioner Inquiry

Practitioner Inquiry facilitates teacher professional learning by supporting teachers to inquire into their own practice and is defined as the "systematic, intentional study of one's own professional practice" (Dana & Yendol-Hoppey, 2014, p.12). The inquiry can lead to evidence informed changes and recommendations for the teacher's own practice. Teachers systematically work through an inquiry cycle, based on an initial inquiry question (Figure 1) and this cycle is iterative. Practitioner Inquiry is a powerful form of teacher professional learning (de Lange, 2020). It is intentional: that is, its purpose is to improve classroom practice with a focus on student learning. It is an inherent part of professional practice for teachers. Teachers inquire into something they are passionate about, and have ownership in the process. It is about collecting data. Teachers examine the student learning to help them to address their central question. And it is systematic. It is a continuous, ongoing process of learning with the collaboration of others (teachers, students, other stakeholders).

Figure 1

Practitioner Inquiry Cycle



Professional Learning Communities

Professional Learning Communities provide an opportunity for groups of teachers or educators to work together in a supportive, collaborative and positive environment. They are characterised by members having a shared vision, responsibility and values, and equitable participation. Effective Professional Learning Communities promote a culture of inquiry among their participants, and have a common interest and curiosity about student learning (Cochran-Smith & Lytle, 2015).

While practitioner inquiry has a focus on a teacher's own practice, it is important that there are opportunities for teachers to collaborate, share ideas and learn from the practice of other teachers. This is especially relevant when designing professional learning for teachers working in transitions, as this setting involves multiple teachers from different schools. Thompson et al. (2019) suggest that when PLCs collectively study a problem or element of practice that it can have the effect of improving teaching practices. Therefore, providing opportunities for teachers to form a professional learning community to inquire into their practice (through practitioner inquiry) can be an important element in teacher professional learning.

Rich Tasks

The design of mathematics tasks should include a range of dimensions that provide opportunities for learners to meet different needs at different times (Johnstone-Wilder and Mason, 2004). These dimensions can be considered as a spectrum, ranging from routine or closed to more open or rich tasks (as indicated in moving from left to right in Table 1). Teachers are encouraged to use a variety of these dimensions of mathematics tasks in designing student learning experiences.

Table 1

Dimensions of Mathematical Tasks. Adapted from Johnstone-Wilder and Mason (2004)

Tangential	*Fits into the core of the curriculum; represents a 'big idea'*	Essential
Contrived	*Uses processes appropriate to the discipline; learners value the outcomes of the process.*	Authentic
Superficial	*Leads to other problems; raises other questions; has multiple possibilities*	Rich
Uninteresting	*Thought provoking; fosters persistence*	Engaging
Passive	*Learner is a worker and decision maker; learners interact with other learners; learners construct meaning and deepen understanding*	Active
Infeasible	*Can be done within school and homework time; developmentally appropriate for learners; safe*	Feasible
Inequitable	*Develops thinking in a variety of styles; contributes to positive attitudes*	Equitable
Closed	*Has more than one right answer; has multiple avenues of approach making it accessible to all learners*	Open

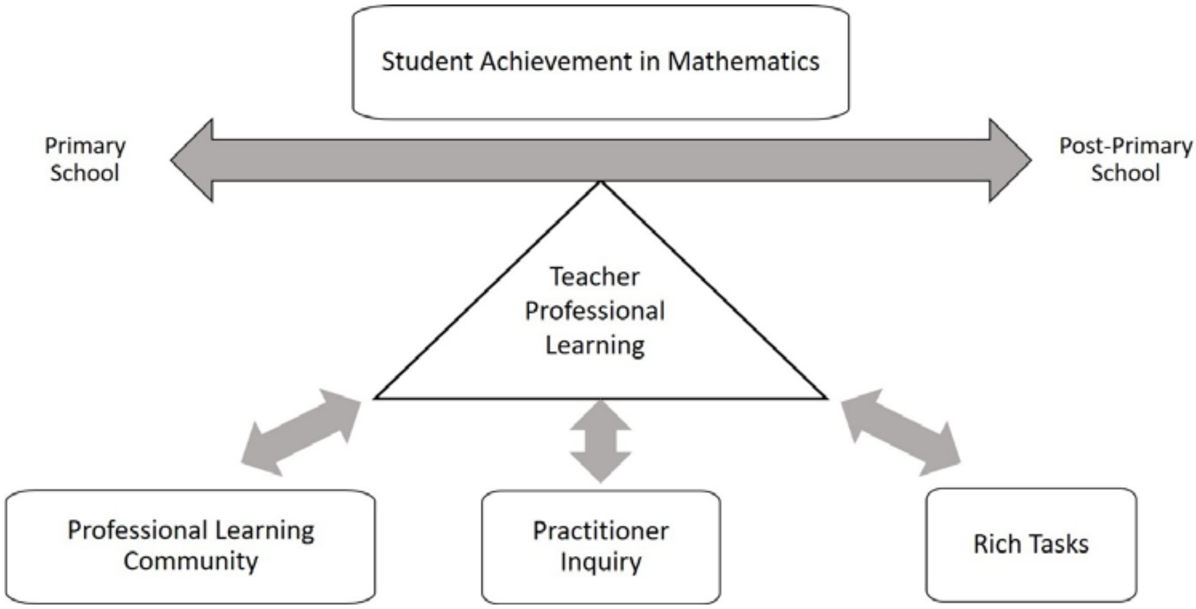
The term rich tasks is often used in mathematics as a general way to refer to tasks that include one or more of the dimensions outlined in Table 1 above. Knot et al. (2013) define a mathematics rich task as one that is *"complex, non-algorithmic, and non-routine, allowing for multiple strategies and representations and no single pathway to a solution."* (p. 600). The authors also emphasise that it is not just the description of a strategy or reasoning that is used to solve the task that is important. Students should be able to generalize and justify the strategy or reasoning used to arrive at an answer. Several characteristics and learner outcomes of mathematics rich tasks have been identified, such as a focus on inquiry, improving questioning, multiple methods, low threshold and high ceiling, promote reasoning and problem solving and encourage collaboration and discussion (NRICH). Such rich tasks can support students in developing mathematical thinking and reasoning and so it is important that teachers use these constructs in designing mathematics tasks for primary and post-primary students.

Initial Design Principles for Teacher Professional Learning

Our study considers the conceptual model proposed by Campbell et al. (2014) to support the development of teacher knowledge and perceptions of mathematics. The focus of our study is to facilitate teacher professional learning to enable student achievement in mathematics as they move from primary to post-primary school. The initial design principles for a model of teacher professional learning are presented in Figure 2 and are based on facilitating teachers to inquire into their own practice, work as part of a professional learning community and design rich mathematical tasks. By providing opportunities for teachers to engage in these activities, they will collaborate with others and investigate their own practice so that they are able to provide further support for students transitioning form primary to post-primary mathematics. This will also provide opportunities for teachers to broaden their own MKT, in the domain of horizon knowledge and other domains. Future studies will report on the use and implementation of these initial design principles; an EDR approach is currently being used to develop a programme of professional learning for primary and post-primary teachers as part of the Erasmus+ funded Supporting Transitions Across Mathematics and Physics Education (STAMPEd) project. The findings from this pan-European implementation will inform models for STEM teacher professional learning.

Figure 2

Design Principles for Teacher Professional Learning



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