Transforming Aspirations of Future Mathematics Teachers Into Strategies In Context

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In this paper I present a collaborative research and development programme, in which we design situation specific tasks and use them to explore, challenge and change knowledge and beliefs of in- and pre-service secondary mathematics teachers. In this work we use practice-based and research-informed tasks in which we invite teachers to consider a mathematical problem and typical student responses (and teacher reactions) to this problem. So far the programme develops in four stands: (1) mathematical knowledge for teaching; (2) classroom management and mathematics learning; (3) disability and inclusion in the mathematics classroom; and, (4) meta-use of tasks and task development. Examples of tasks from these strands will be discussed in the session.

Introduction

In this paper I present a collaborative research and development programme since 2005 on secondary mathematics teachers' knowledge and beliefs and the transformation of these knowledge and beliefs into pedagogical practices. Research acknowledges the overt discrepancy between theoretically and out-of context expressed teacher beliefs about mathematics and pedagogy and actual practice (e.g. Speer, 2005) and a substantial body of work in mathematics education explores the use of specific teaching cases (e.g. Markovits and Smith, 2008) in teacher education. Our research sets out from the assumption that teacher knowledge is better explored and developed in situation-specific contexts and to this aim we design *situation specific tasks (thereafter Tasks)* – i.e. tasks based on specific mathematical teaching scenarios – and then use them for research and teaching purposes. These classroom scenarios: are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal; are likely to occur in actual practice; have purpose and utility; and, can be used both in (pre- and in-service) teacher education and research through generating access to teachers' views and intended practices.

So far, seven mathematics educators from the UK, Greece and Brazil have been involved in this programme and the research we have conducted – and we anticipate to conduct in the following years – is divided in four strands: (1) *mathematical knowledge for teaching* (e.g. mathematical thinking; pedagogical and didactical practices in the mathematics classroom); (2) *classroom management and mathematics learning* (e.g. interference of the classroom management with the learning of mathematics); (3) *disability and inclusion in the mathematics classroom* (e.g. deaf and blind students strategies in dealing with mathematical problems); and (4) *meta-use of tasks and task development* (e.g. asking teachers to create their own classroom situations and tracking the impact this engagement has on their knowledge and beliefs). The format of the *Task* varies across the programme – e.g., monologue or dialogue; script or video clip format; one or more students; teacher intervention or not; etc. – in order to address different issues and different aspects of these issues in relation to the teaching and learning of mathematics. In the following sections I describe briefly each one of these strands.

Mathematical knowledge for teaching

In the *Tasks* of this strand we invite teachers to: solve a mathematical problem; examine a (fictional yet research-informed) solution proposed by a student (or more than one students) in class and, in some versions, a (fictional yet research-informed) teacher response to the student; and, describe the approach they themselves would adopt in this classroom situation (Biza, Nardi & Zachariades, 2007, 2009; Nardi, Biza & Zachariades, 2012; Zachariades, Nardi & Biza, 2013).

From the teachers' responses to these *Tasks* we aimed to explore teachers' subject matter knowledge and their gravitation towards certain types of pedagogy and didactical practices (Biza *et al.*, 2007). So far, teacher responses in these *Tasks*, joined with *post-Task individual semi-structured interviews*, have allowed us to access a range of teacher knowledge and beliefs (epistemological and pedagogical). For example, in (Biza *et al.*, 2009) we discuss the multiple didactical contracts on the role of visualisation in mathematics and mathematical learning that teachers are likely to offer their students under those influences (e.g. is a graph-based argument an acceptable argument in the mathematics classroom?). Additionally, teachers' responses to these tasks and interviews with them revealed a complex set of considerations that teachers take into account when they determine their actions (Nardi *et al.*, 2012) – what Herbst and colleagues (e.g. Herbst and Chazan 2003) describe as the *practical rationality of teaching.* We demonstrate how teacher arguments, not analysed for their mathematical accuracy only, can be reconsidered, arguably more productively, in the light of other teacher considerations and priorities: pedagogical, curricular, professional and personal that influence the decisions teachers make in the classroom. Recently, we introduced a format in which an elaborated design that enriches and develops the previous one in which apart from the student flawed (fictional) response(s), a fictional response from a teacher has been added (Zachariades, *et al.* 2013). With this design we aim to explore, not only whether the teacher can identify a student mathematical error and what their pedagogical intentions are, but, also, how they evaluate the pedagogical approach followed by another (fictional) teacher.

Classroom management and mathematics learning

The motivation for this strand came from the research and practice based observation that classroom management often interferes with working towards commendable learning goals (e.g. Kersting, 2008). The *Tasks* we designed for this strand are based on realistic classroom scenarios that combine seminal mathematics learning and teaching issues with classroom behaviour issues (e.g. classroom management, conflicts between students or between students and teacher). For example, in one of these *Tasks* a class is asked to solve the problem: "When p=2.8 and c=1.2, calculate the expression: $3c^2+5p-3c(c-2)-4p$". Two students reach the result (10) in different ways: Student A substitutes the values for p and c and carries out the calculation; Student B simplifies the expression first and then substitutes the values for p and c. When Student A acknowledges her difficulty with simplifying expressions, Student B retorts offensively ("you are thick") and dismissively ("what can I expect from you anyway?"). Both solutions are correct and Student B's approach particularly demonstrates proficiency in important algebraic skills. But Student B's behaviour is questionable. 21 prospective mathematics teachers were asked to write, and then discuss, how they would handle this classroom situation. Results indicate commendable norms teachers aspire to establish in their classroom: peer respect; value of discussion; and, investigative mathematical learning. However, they often miss the opportunity to engage students with metacognitive discussions and mathematical challenge as they focus on behavioural issues or endorse dichotomous and simplistic views of mathematical learning (Biza, Nardi & Joel, 2015).

Disability and inclusion in the mathematics classroom - CAPTeaM

This is a recent development of our programme and relates to inclusive education and teacher perspectives on how students with disabilities (in our studies so far deaf, blind and with Down syndrome) learn mathematics. Our project is called CAPTeaM (Changing Ableist Perspectives on the Teaching of Mathematics) and is funded by the British Academy. Specifically, according to the ableist world-view, the able-bodied are the norm in society and disability is an unfortunate failing, a disadvantage that must be overcome. Within education, ableism results in institutional and personal prejudice against learners with disabilities, and has a drastic effect on approaches to teaching (Nardi, Healy & Biza, 2015). Our project investigates how ableist perspectives impact on the teaching of mathematics, a discipline where public perceptions of ability as innate often shape pedagogical perspectives and practice. In this strand the expertise of a team of Brazilian researchers (Lulu Healy and colleagues) on mathematics learners with disabilities joined with our *Task* design approaches to develop and trial *Tasks* that invite teachers to reflect upon the challenges of mathematics teaching in inclusive classrooms. The *Tasks* in this strand are of two types. In Type I, using the approach described by Biza *et al.* (2007), the scenario is inserted as a video clip into a brief narrative about a fictional mathematics classroom. We then invite participants (prospective mathematics teachers) to assume the role of the teacher of this class and evaluate the interactions of the disabled students that were presented in the video clips – first individually and in written responses to a set of questions, and then in a group discussion (which we also video-record). In the tasks of Type II, which aim to provoke reflections about how access to mediational means differently shapes mathematical activity, participants work in groups of three. Two members of the group are asked to solve a mathematical problem whilst, temporarily and artificially, deprived of one of their sensory or communication canals. A group discussion of their experiences follows.

For example, in one of the Type I *Tasks* students work on exploring how they would describe what a square-based pyramid is to someone who doesn’t know. André, who is blind, and has been working with 3D solids, offers a description (seen by participants in a video clip) shaped around the idea of a square based pyramid being built out of gradually shrinking squares. Preliminary analysis of 81 responses indicates, for example, preference for switching André’s perspective on a square-based pyramid towards the textbook definition of a pyramid (faces, edges and vertices) and preference for a discussion of a square-based pyramid as a composition of fixed shapes (four triangles and a square) (Nardi *et al*., 2015).

Teachers’ Narratives: Meta-use of tasks and task development

This strand is in resonance with works such as Zazkis, Sinclair and Liljedahl (2013) on teachers’ creation of their own lesson plays. We started working on this direction last year when we invited prospective teachers to write a brief teaching/learning scenarios from their own first experiences from schools. We collected 12 scenarios, we grouped them thematically and we invited trainees to discuss these in groups, produce posters of the key points of the discussion and then share these points with the whole group. The themes we identified concern issues such as mathematical learning (e.g. misconceptions, instrumental and relational understanding); classroom management; student engagement; and, prospective teachers' relationships with more experienced teachers. Group and class discussion were audio-recorded and transcribed. We are now analysing these in close collaboration with practising teachers. We see these narratives as opportunities for teachers' reflection on their practice. Furthermore, we see the benefits of the collaboration of researchers and teachers in the analysis of these narratives in both research and professional development.

Conclusion

In conclusion, from our research the last 10 years, we credit this task design with allowing insight into pre- and in-service teachers' considerations. Teachers very often express commendable aspirations without, however explaining how they would transform these aspirations into practice. We propose the further implementation of this situation specific task design in teacher education programmes towards the transformation of these aspirations of future mathematics teachers into teaching strategies.

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