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How can we engage mathematics ITE students with research?

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In the Erasmus+ Research in Teacher Education (RiTE) project, student teachers are stimulated to use evidence from educational and scientific research to experiment and innovate their teaching and learning processes. In two case studies we use Engestrom's expansive learning cycle. The first case study reports on the design and implementation of materials designed to enhance student teachers' critical review of literature in the context of the post-graduate study that is incorporated within their teacher education. The second case study presents the design of collaborative lesson research that aims to foster authentic connections between school-based learning (teaching practice) and research that informs mathematics teaching and learning. We discuss the aims of research-informed mathematics teacher education at each site, demonstrate some of the approaches used and discuss tensions within the design and early implementation of the projects.

Keywords: evidence-informed practice; evidence-use; teacher training; mathematics education

Introduction

Within the context of secondary mathematics initial teacher education (ITE), there can be limited attention to teachers' professional development in competencies required for evidence-informed teaching (e.g. Whitty, 2016). A research-informed approach in which teachers conduct small scale studies (Engeström & Sannino, 2010), such as action research and collaborative lesson research to innovate their teaching practice informed by results from educational research and scientific resources, could encourage teachers to engage in the process of educational change. In such an approach, teachers set their own learning objectives and enquiries in interaction with the knowledge base of their discipline. However, whether conducting enquiries and research activities will improve education, depends on the content and design of the specific study. This also depends on the way we see evidence, an issue which in education is ongoing (Gorard, et al., 2020). Discussion of evidence in ITE has been reignited recently by the place of research evidence within the Initial Teacher Training Core Content Framework (Department for Education, 2019)[1]. Biesta (2007) challenges notions of 'what works' evidence in education because:

> [r]esearch cannot supply us with rules for action but only with hypotheses for intelligent problem solving. Research can only tell us what has worked in a particular situation, not what will work in any future situation. The role of the educational professional in this process is not to translate general rules into particular lines of action. It is rather to use research findings to make one's problem-solving more intelligent. (p. 20).

[1] For a critical view on the framework see https://www.bera.ac.uk/blog/total-recall-the-ite-content-framework-research-and-teachers-understandings-of-learning

The contradiction between research that informs professional judgement for intelligent problem solving and evidence that supports knowledge content and practice in the ITT core content present potential tensions that teacher educators and ITE students could endeavour to understand in their own work and in the work of the researchers they choose to inform their practice. This is aligned with tensions that ITE students experience when designing lessons and teaching in a manner that supports their pupils, whilst trying to meet the expectations of university and school-based teacher educators. The RiTE study aims to understand how these contradictions are mediated and how they influence ITE students' decisions, their action in the classroom and their perceptions of how research informs their professional knowledge and decision making. In this paper we describe how we try to do this for two UK secondary mathematics ITE contexts.

Literature background

The case studies discussed in this paper are part of a wider Erasmus+ project with five university partners, which addresses the need to strengthen initial teacher education, identified by the European Commission (EC) (2015). They identified ITE as a fundamental area for education policy to support a shift towards new working cultures and practices, to lay the foundations for teachers to use research to inform decision making, to adapt to changing contexts and to increase the attractiveness of a teaching career. Consequently, we recognise the need to apply the strategies of evidence-informed policy making and practice to ITE settings (Breckon & Dodson, 2016). In this project, student teachers are encouraged to use evidence from research to solve problems in their practice, to use relevant research to design lessons and to inform teaching. This paper focusses on the two UK projects that are situated in one-year postgraduate certificate of education (PGCE) secondary mathematics programmes in England.

Within the context of ITE in England, the notion of evidence-informed practice is complex. In particular, the context of the activity of university-based teacher educators and the activity of the classroom remains a site of potential contradictions and tensions, with conceptions of evidence-informed practice amongst them (Ellis, et al.,, 2011). Within the RiTE project there are differences in interpretation of what it means to apply research to the design and teaching of science and mathematics lessons between teams in the five partner universities as well as within participants in each case study. The expansive learning methodology provides a way of negotiating these and other contradictions in a manner that can lead to transformation (Engeström, 2001). Discussion of the identification of the subject and object of the learning activity varies within each case study, but the two cases discussed here are aligned in that they are both centred on the secondary school mathematics classroom and that the subjects are the PGCE students learning to teach mathematics. The object within each study has some alignment, in that both PGCE programmes integrate research informed practice. In the first case study, ITE students write a critical evaluation on mathematical resilience or mathematical misconceptions. Students are then asked to design a small research project. In the second case, small scale collaborative lesson research and practitioner enquiry are used to interrogate the activity of ITE students designing and teaching research informed mathematics lessons.

Gorard and colleagues (2020) found that the majority of studies on evidence-use in education "have not had positive results. This enables research users such as schools to make much more informed judgements about which interventions are likely

to work in their context, and which will not." (2020, p.571). In this way, interrogating published research that may or may not confirm an intended effect of an intervention can have a positive influence on decision processes in schools. Even with studies that claim to have a high degree of validity, it is not clear how these outcomes translate into the school context. Understanding how to use research to inform practice in schools is necessary at all stages of teacher development, not least in ITE. Whilst this is important for education, Gorard et. al. warn that "problems for evidence-into-use lead to wasted opportunities, and even harm, for the education system." (2020, p.574). This raises important questions about what is appropriate and ethical when integrating evidence-informed practice into teaching (Biesta, 2007). These questions will be interrogated within this project and is a feature of the ITE case studies discussed here.

Engeström's expansive cycle

Engeström (2001) states that an "expansive transformation is accomplished when the object and motive of the activity are reconceptualized to embrace a radically wider horizon of possibilities than in the previous mode of the activity." (p.137). The nature of the reconceptualising interpreted in the two case studies involves recognising the multiple voices within university and school-based ITE activity systems. This involves analysing how ITE students and teacher educators negotiate meaning in designing lessons so that participants might understand and negotiate potential contradictions in their professional knowledge and practice. Each case study integrates Engeström's expansive learning cycle as a methodology as well as a model for understanding the participants' responses to research-informed practice and evidence use. Expansive learning cycles are methodological processes that mediate between or change activity systems. The main focus of expansive learning cycles is "learning in which the learners are involved in constructing and implementing a radically new, wider and more complex object and concept for their activity." (Engeström & Sannino, 2010, p.2).

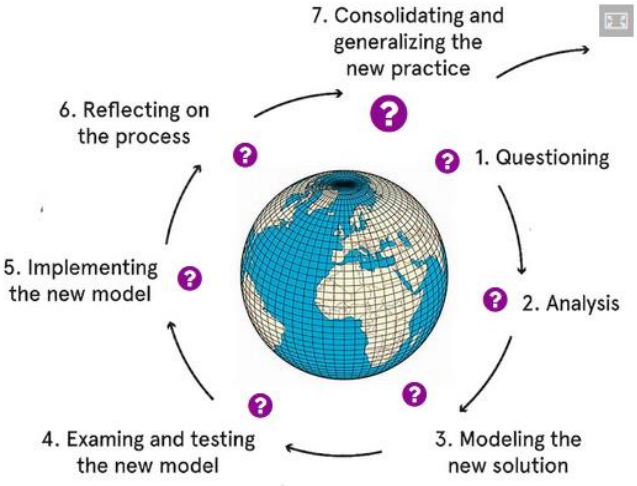

Figure 1: expansive learning cycle as presented on the RiTE website (here: http://ddn-rite.eu/case-study-university-of-southampton/)

Figure 1 presents the cycle. Contradictions within ITE practice can allow *questioning* and *analysis* of the activity system(s). In the *Modelling* step, the new solution, or new activity is designed, in alignment with the *Analysis* stage. Contradictions with the activity system(s) facilitate the modelling of a response that transforms the activity, stimulated by the incompatibility of activity at the site of the contradiction. While

examining the model it is possible to reject a new solution, because of further contradictions or difficulties. In this case, the *Modelling* steps start again and another new solution will be constructed, until a solution is accepted through *Examination* (Engeström, 2001). When a new solution is accepted, it will lead to the *Implementation* stage. When *reflection* is positive, the new activity may stabilise after a while. The *Consolidating* step may generalise the new practice, but it does not necessarily have to be the endpoint of this cycle. It may be possible, that after a while contradictions arise with the 'new' activity, whereby the cycle may start again.

The current project

The RiTE project consist of two phases, designed to stimulate a career-long perspective on teachers' professional development, whilst promoting collaborative learning among teachers. The first phase looks at five teacher training institutions to produce five case studies on creating an evidence-informed teaching practice. In the second, we will follow former ITE students in their first year of teaching. In phase I all partners will use their local ITE context to construct a support structure in their ITE curriculum. In phase II a sample of participants from phase I will be supported in their first teaching year in using the support structures developed in phase I. This paper only reports on the first half of the first phase. Each partner conducts a case study in their teacher training programmes, choosing their own approach, such as lesson study, micro-teaching and action research, with each aligned to the expansive learning cycle (Engeström & Sannino, 2010). The wider project aims to understand how student teachers are supported with integrating evidence from research in their teaching practice. Addressing this aim will allow us to support teachers and teacher educators to develop and innovate their educational practice based on evidence, and contribute to reducing the gap between theory and practice in ITE (Whitty, 2016).

Case study 1: Southampton

At the University of Southampton, the post-graduate course to become a secondary mathematics teacher (PGCE) contains three Master level assignments, two of which are mathematics education specific. In the RiTE project we redesigned the support for these two assignments A1 and A2. A1 is a critical evaluation of one out of two mathematics education topics: mathematical resilience or mathematical (mis-)conceptions. A2 then asks trainees to design a small research project on the topic of A1, collect some empirical data, analyse it and then draw some conclusions. The set of activities has been mapped to the Engeström cycle shown in Figure 1. The following activities have been created:

1) **Preliminary work**. A shorter writing task is set pre-course so that trainees have an opportunity to start to engage with literature and to begin to connect theory and practice. They receive brief feedback and the task is used diagnostically to identify those who might need additional support with assignments. In addition, an academic writing workshop is provided. Rather than addressing any substantive content, it provides a skills basis for what will follow in the next stages of the expansive learning cycle.
2) **Questioning and analysing.** Two topics, 'attitudes to mathematics and resilience' and 'conceptions and misconceptions in mathematics' are presented in teaching sessions and through a curated set of research articles. This step is aimed at "questioning, criticizing or rejecting some aspects of the accepted practice and existing wisdom." (Engeström, 2010, p.7). This is done to not only provide the evidence base of the two topics, but also critiques and comments on that evidence base, alongside providing

supporting annotated research articles and screencast videos (of both supporting articles as well 'questioning' articles). The idea is that this leads to a coherent synthesis of some of the evidence-base.

3) **Modelling the new solution.** We provide three sessions on structuring assignments, choosing and using research methods and methodology. The sessions present a combination of skills building and making choices regarding the empirical part of the assignment. In the context of the expansive learning cycle they are aimed at "running, operating and experimenting on it in order to fully grasp its dynamics, potentials and limitations." (Engeström, 2010, p.7)
4) **Implementation, reflection and consolidation.** Finally, after concluding the empirical data collection, trainees focus on analysing what this means for their classroom practice, whereby they write up the findings in A2, including a reflection.

Regarding the evidence-use mechanisms by Breckon and Dodson (2016), we focus on awareness and skills i.e. building self-awareness of trainees' evidence-use and the skills to evaluate evidence.

Case study 2: Chester

Secondary school mathematics (ITE) is predominantly taught through a one-year PGCE which integrates school-based learning with study at Masters' level. The case study has been designed to foster more authentic connections between school-based learning (teaching practice) and research that informs mathematics teaching and learning that is more often associated with university-based learning (Ellis et. al., 2011). The cycle of teacher education used in the case study is characterised by small-scale Teacher Research Group (TRG) collaborations that allow beginning mathematics teachers to use research to inform the design of a lesson and to interrogate learners' responses to the lesson. The TRG moves away from a lesson observation implicit to a judgement of performance and towards a model of collaborative enquiry that focuses on learners' responses to research-informed lesson design (Baldry & Foster, 2019). This leads to a second stage of the case study that allows beginning teachers to plan a practitioner enquiry. The rationale for their enquiries is rooted in understanding mathematics education difficulties that they are facing in their own classrooms. The ITE students become aware of appropriate methods for carrying out classroom enquiries whilst further interrogating research that informs the structure and design of their lessons. However, their insight into methodology within this study is limited to an explicit awareness of the nature and methods of practitioner enquiry and does not attempt to equip the ITE students to become independent teacher-researchers.

The small-scale collaborative lesson research in the first stage of the case study is part of the wider mathematics teacher education programme that aims to bridge university- and school-based education. Usually, research that informs the lesson design is translated by the university tutor in collaboration with experienced teachers from the partnership school involved in the collaboration. In this way, the tutors' professional judgement is informed by their interpretation of research evidence, situated in the context and culture of the partnership school. Designed lessons are implemented through small group teaching in a model that aims to foster a safe, collaborative context that enables the ITE students to interrogate the learners' responses, ideally reflecting on the consequences of the decisions that they made during the teaching episode in relation to learners' responses.

In the second stage, the practitioner enquiry allows the ITE student greater control over the aims of their lesson research. The focus for the enquiry is stimulated

by problems that they want to solve in their own classrooms, usually in response to difficulties that they have experienced in learning to teach mathematics. However, this focus is controlled to some extent by the university tutor and school- based mentors through monitoring the ethical dimensions of the study and by restricting the action research to understanding how they design and teach an aspect of the mathematics National Curriculum. ITE students are guided to use data through field notes and artefacts from the lessons so that they can interrogate learners' responses to the designed lesson in depth, using research to inform their professional judgement in the analysis (Biesta, 2007). The research proposal, research-informed lesson design, interrogation and critical analysis of findings and implications for their professional learning is embedded within the Masters' level study of the PGCE programme.

Final thoughts

The relationship between research and practice remains a dilemma in ITE programmes, whereby the influence of policy such as professional standards for Qualified Teacher Status influence the activity systems at two potentially contradictory sites of learning (the university and the school). Another source of contradiction stems from the object of learning in the case study being the ITE students' professional knowledge and practice, possibly in tension with participants' core interest in the impact of their behaviour on mathematics pupils in the classroom (Ellis et. al., 2011). Each of these features has the potential to influence participants' understanding of how pupils learn from ITE students and how the pupils respond to the ITE students' decisions made in lesson design and teaching. One thing is clear to the authors: with the increased interest in 'evidence-informed practice' it is important to steer clear from easy takes on 'what works' and instead focus on a rich tapestry of evidence.

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