Pre-service teachers' perceptions of theory – the case of compressed knowledge in mathematics

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This paper aimed to examine how pre-service teachers perceive the theory of compressed knowledge in mathematics; hoping to bring new knowledge to the issue of how to link theory and practice in initial teacher education. Twelve pre-service teachers attended two focus groups (one prior to a teaching placement and one after it). Participants were selected using the following break characteristics: self-assessed reflectivity and receptiveness to theory; self-reported judgement of whether the idea of compressed knowledge was useful. The data showed that both the training provider and the accessibility and relevance of the theory are influential in how much pre-service teachers value theory. In addition, compressed knowledge theory was interpreted in two distinct ways: as a 'tool' or as a 'source of enlightenment'. A model of how interpretation of theory may evolve is proposed including the need for a 'state of perplexity' during practice to move a theory into knowledge for future action.

Keywords: Pre-service teacher; theory; compressed knowledge

Introduction

What is compressed knowledge in mathematics?

In 2000, Ball and Bass proposed that teachers often hold their mathematics content knowledge in a desirably compressed form, allowing them to be fluent and competent. Ironically, however, knowledge held in this final polished form is inadequate for teaching as it makes it difficult for teachers to discern how learners are thinking and requires them to unpack their content knowledge to ensure that it is visible and accessible to their learners (Ball & Bass, 2000). Thomas (1997), following analysis and amalgamation of the previous twenty-five years of theory definition, concluded that theory in education should be defined as an idea or a possible explanation that comes from a culmination of intellectual endeavour. Ball and Bass' (2000) ideas of compressed knowledge are exactly that; a possible explanation coming from a culmination of intellectual endeavour. For the purposes of this paper, therefore, I shall classify compressed knowledge in mathematics as theory, and will refer to it as CKT.

Theory in initial teacher education

The divide between theory and practice for pre-service teachers (PSTs) has pervaded the literature for decades (Dillon, 2017). However, there appears to be a trend towards viewing this issue from the perspective of the teacher educator observing the pre-service teachers during their programme (e.g., Hodson et al., 2012), what seems to be

less common is the route of directly asking PSTs how *they* perceive theory. This has potential to shed new light on what has been an extremely pervasive and significant issue. Seeking the voice of pre-service teachers is therefore the crux of this paper.

I decided to use CKT as a platform to explore this issue due to a number of similar experiences I had with PSTs. During seminars, PSTs seemed to gain great insight and comfort from the idea that their knowledge may be compressed when they felt frustrated at their inability to clearly explain mathematical ideas to children or to their peers during micro-teaching. In addition, two PSTs came to me in subsequent weeks to thank me for the insight, explaining the impact that it had had on their development as a mathematics teacher. I was intrigued. What is it about CKT that appears to make it more useful and immediately accessible than other 'more standard' learning theories that are commonly seen not to impact on practice?

The following research question therefore emerged: How do Primary PSTs perceive CKT in mathematics? -do they value CKT? -how do they interpret CKT?

Research background

PSTs' perceptions of theory

Conclusions regarding PSTs' perceptions of the validity of theory are hugely disparate even when using large samples. Tang et al. (2016) found that, whilst a proportion of their PSTs valued theoretical input and could articulate the impact it had on their practice, a significant proportion stated that theory was not valid information. Hobson (2003) also found that approximately 20% of respondents to their questionnaire stated that theory was of no value to their development as a teacher.

In his interviews with PSTs, White (2005) found that some PSTs interpreted theory as something that had be used or applied as it was, it must remain intact; whilst others felt that you could pick specific aspects of a theory and could mix theories together if it suited the situation. To further understand PSTs' interpretations of theory, links can be made to the suggestion that use of theory falls into two categories: it becomes knowledge for action or it becomes knowledge for understanding (Eraut, 2003). In a study of PSTs in four settings in Northern England, Hobson (2003) was able to categorise the PSTs into two main interpretations of theory. He found that the majority of PSTs interpreted theory as wider knowledge that may or may not influence their practice; perhaps suggesting theory becoming knowledge for action. Contrastingly, a small minority interpreted it as a vehicle to aid their understanding of practice; perhaps suggesting theory becoming knowledge for understanding.

PSTs' perceptions of CKT

Although there is no literature about PSTs and CKT, case study analysis of practising teachers shows that decompressing their knowledge supports them to plan series of lessons (e.g., Provost, 2013) and helps them to successfully select and sequence examples (e.g., Burke, 2013); however, no mention is made of whether the observed teachers are aware of this theory or are consciously using it to support their planning.

Factors which may affect PSTs' reported perceptions of theory

Training provider's influence

Differences in reports of PSTs' opinions on the validity of theory in may reflect a genuine continuum but may alternatively be due to other factors. For example, both Smith and Hodson (2010) and Williams and Soares (2002) acknowledge the potential influence of lecturers when reporting that their participants all seemed to value theory to an extent. In conjunction, in a study which deliberately collected data from nine PSTs *before* any formal training had begun, Holt-Reynolds (1992) found that the most common response to theory was downright rejection. Furthermore, Hodson et al. (2012) found that a structured input which valued theory alongside experience and reflection resulted in the forty school-based PSTs in their study becoming very adept at creating personal theories using formal theory to inform this.

Accessibility and relevance of the theory

Dye (1999) found that PSTs who saw very little value in theory claimed that it was full of 'elitist jargon'. In addition, in-service teachers have been found to find theory inaccessible due to the language used (Zeuli & Tiezzi, 1993). Indeed, accessibility of information was seen to play a key role in how much that source was valued by one hundred and twenty-seven PSTs, when asked to rate the usefulness of information (Landrum et al., 2002). Similarly, PSTs and teachers are reported to state that theory is meaningless if it is not relevant to experience (Davis, 1999).

Methodology

Use of focus groups

Of particular concern in this study is the need to bridge the gap between myself and my students. Focus groups were therefore chosen as they allow insight into the perceptions of participants using their own language (Litosseliti, 2003), and are thought to be an excellent method to help bridge experiential gaps between researcher and participants (Morgan, 1998). Just as the social aspect of focus groups acts as a major benefit, it also leaves it open to criticism (Barbour, 2007). A multitude of social influences are inevitable (Gibbs, 1997). To reduce these effects, I held the focus groups in a neutral, non-teaching area of the campus; elevating it above a normal social interaction with their peers and above a normal seminar situation. I also explicitly highlighted the ongoing relationships between myself and the participants, assuring them that my role in the group was as a researcher. To further reduce any effects of prior relationships with researchers, I chose an assistant who was from another university and was therefore unknown to the participants. I guided the discussion to reduce the sequential and peacock effect and, as advised by Albrecht et al. (1993), I requested that my assistant note down any voice tones or non-verbal subtleties which may indicate social influence.

Participants, questions and a follow up focus group

I chose to sample second-year undergraduate PSTs because I hoped to capture their perceptions post their first year (when they are predominantly likely to find theory abstract (Davis, 1999)), but pre their final year (when they are most likely to find theory insightful (Furlong et al., 2000)). CKT was introduced during a seminar with the second year PSTs as a possible explanation for why teachers may struggle to

explain concepts to pupils. Drawing on Thomas' (1997) definition of theory, I chose to use the words idea, explanation and theory interchangeably throughout the seminar. The PSTs were asked to plan how they would teach a place value objective, exploring how their knowledge of place value would need to be unpacked in order to teach something which may now simply seem like common sense to them.

To enhance the validity of my data as representative of the population, I chose to survey all my 2nd year PSTs and use the following 'break characteristics' (Knodel, 1993) to select four groups of four PSTs:
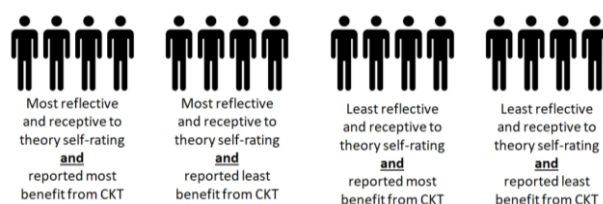
I used self-assessed reflection and receptiveness to theory in general as a break characteristic based on the continuing theme in education literature that 'reflection' is a process that is essential for PSTs to be receptive to new ideas (Clarke & Hollingsworth, 2002), e.g., theory. My second break characteristic came from a question in the survey in which I asked them whether they had found CKT useful to their development as a teacher of mathematics. Again, I selected the extremes of this characteristic: those in the survey who not only replied 'yes' to this question, but also gave an informed example of how it had been helpful, versus those who said 'no' with an exclamation mark. In addition, as advised by Knodel (1993), I used the survey results to ensure that the following characteristics were equally spread across the groups: age; gender; mathematics attainment; teaching grade attainment; beliefs about whether people are born good at mathematics or not; anxiety about mathematics; participant's definition of subject knowledge.

As I was keen to 'hear the voice' of my PSTs, I decided to limit the structure of my focus groups. In this situation, Litosseliti (2003) suggests a 'funnel design' whereby questions begin on broad, general topics before progressively becoming more focussed beneath the research question. Litosseliti (2003) also advises that focus group research should evolve during operation, with subsequent decisions being based on ongoing observations. I utilised this advice by deciding to do a follow-up focus group with each of the groups after they had been on an extended teaching placement. This was in response to an observed trend that the PSTs were suggesting ways in which they could use CKT, but wanted to experience a teaching practice (with their new knowledge of CKT) to enable confirmation. The final transcribed data therefore consisted of four pre-SBT (school-based-training) focus groups of 45 minutes, four debriefing discussions between myself and my assistant immediately after each pre-SBT focus group (30 minutes each) and four post-SBT focus groups of 20 minutes.

Analysis of the data

I utilised the principles of inter-rater reliability by asking my assistant to conduct a second, independent analysis of the data separately from myself (Gillham, 2000). We began by separately devising an initial coding of the data that encompassed ideas of co-terminals, nesting and overlapping if and when they became necessary. As suggested by Barbour (2007), the data was repeatedly recoded until we were happy

with the assigned basic codes. In addition, as suggested by Corbin and Strauss (2008), we left all codes written on the data to ensure a record of the evolving codes. In order to verify the broad themes, consistency was sought between myself and my assistant. We both independently analysed the entirety of the pre-SBT focus group transcriptions, including the 'settling in' initial questions and the 'top of the funnel' questions. This allowed us to check for parity in our analysis of these sections to further affirm the validity of our analysis of the parts of the focus group that were directly related to the research question. The reliability of my results is affirmed by the pervasive similarities between statements and viewpoints about theory given by the PSTs in my study, and those of the PSTs reported within a number of previous studies (e.g., Allen & Wright, 2014). Due to this striking correspondence between PSTs' perceptions of theory in general, it can be extrapolated that (despite no existing data to compare it to) my data regarding PSTs' perceptions of CKT is also reliable. Direct quotes from the focus groups use the pseudonyms PST1, PST2 etc.

Results and discussion

Did the PSTs value CKT?

Literature suggests that in an average population of PSTs there will be a distinct, albeit minor, proportion of PSTs who resolutely do not perceive theory as a valid source of information (e.g., Tang et al., 2016). My PSTs were deliberately chosen to try to capture this end of a possible spectrum as 25% of them were at the extreme in self-assessing as 'non-reflective' alongside their original declaration that CKT was not a valid source of information. And yet, at the end of the research, **all** the PSTs stated that CKT was valid and useful. What could have caused this?

The way CKT was introduced to the PSTs

CKT was introduced as part of a seminar. The subsequent focus groups created an opportunity for the participants to engage in deeper practical reasoning alongside their personal goals. Once they began SBT the PSTs had a chance to try out ideas from CKT and reflect on their impact. Additionally, by meeting my PSTs again after their SBT, they were encouraged to reflect further on the impact of their use of CKT during their practice. Inadvertently, the design of my research has utilised a range of aspects of teacher development that are recommended: including drawing on teachers' prior experience and beliefs (Forgasz & Leder, 2008); creating a community of practice (Wenger, 1998) where critical analysis is encouraged (Jaworski, 2006); allowing enactment of an idea (Allen & Wright, 2014) and facilitating reflection following enactment of an idea (Clark & Hollingsworth, 2002). Indeed, Smith and Hodson (2010) attributed a large part of the reason that their PSTs felt positive towards theory to the opportunities given to discuss and rework theory based on prior experience.

Accessibility and relevance of CKT

A strong trend in the literature is the idea that teachers and pre-service teachers find theory inaccessible, potentially due to the language used (e.g., Landrum et al., 2002). However, inaccessibility seemed less evident in the following comment which neatly captures a further feature of CKT, that the language (compressed; decompress;

unpack; deconstruct) induces visual interpretations, which Cunningham and Stewart (2003) argue make learning theory easier to understand and therefore access: "It's just like having a big box - long multiplication...when you unpack it you find all the little bits that you have to understand to be able to do it" (PST1).

Relevance of theory is a key predictor for receptiveness by teachers (e.g., Furlong et al., 2000). A strong umbrella code identified by both analysts was 'PSTs applying CKT to previous experience'; nested beneath this code was a range of sub-codes indicating the relevance of CKT to a breadth of experiences across the PSTs. Interestingly, a further code arose from across all the focus groups both before and after placement; that of my PSTs demonstrating positive language and facial expression when talking about CKT whilst predominantly showing negative language and facial expression when talking about 'theory'. Furthermore, no instances were found of PSTs using the word theory alongside CKT; whilst a weak code evident across all the groups was that of PSTs stating explicitly that they did not perceive CKT as a theory.

How did the PSTs interpret CKT?

Repeated sub-categorisation by both analysts revealed a significant overarching theme in the codes linked to the PSTs' interpretations of CKT. It was either interpreted as a 'tool', something to be used to support their mathematics teaching practice, "I think it will hugely affect my planning..... how you're going to break it down into steps for the child." (PST2); or it was interpreted as a 'source of enlightenment', "I just remember that I had a lightbulb moment....because I always thought that because I couldn't explain it, that I was like, thick. But it wasn't. It was just that I had compressed knowledge ... I was finding it difficult to break it down." (PST3).

I am immediately drawn to the possible similarities between this theme and 'knowledge for action' versus 'knowledge for understanding' (as defined by Eraut, 2003). Being able to articulate a theory as knowledge for action or knowledge for understanding should allow my PSTs to use that theory during their upcoming SBT and my PSTs emphatically claimed that they would apply CKT to practice from the beginning of SBT. Interestingly though, none of them did. Drawing on literature on belief change, Dewey (1933) claimed that teacher development can only occur in response to a 'state of perplexity'; a theme that has remained in teacher development (e.g., Korthagen, 2005). During the post-SBT focus groups, my PSTs reported noticing a 'point of need' when their planning was unsuccessful. This 'point of need' seemed to induce the use of CKT as knowledge for understanding, enabling them to analyse their 'state of perplexity'. None of my PSTs used CKT to inform their planning and teaching until they reached this 'state of perplexity'. Subsequently, the PSTs seemed to perceive CKT as knowledge for action, using it to inform their teaching decisions from that moment forward. Despite probing, none of the PSTs spoke of needing more than one 'state of perplexity' to cause a resultant impact of CKT on that aspect of their practice. I propose, therefore, that my PSTs went through the following process in their perception of CKT (fig 1):

Figure 1: CKT becoming knowledge for future action
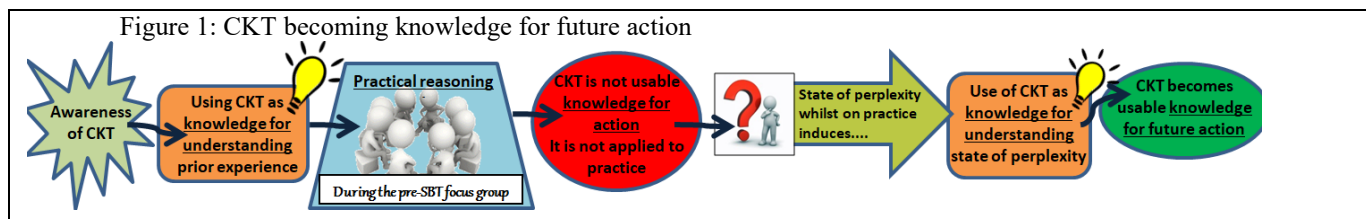
The idea of transitioning through knowledge for understanding before theory can be used as knowledge for action reflects findings from Furlong et al.'s (2000) survey of nearly six hundred newly qualified teachers where a large proportion described a 'click' moment when they perceived how theory and practice linked together.

Conclusions

In common with the literature, the data indicated that there are two key influences on how much PSTs value theory: the training provider and the accessibility and relevance of the theory. As a training provider, the structure of the research allowed my PSTs to discuss CKT through practical reasoning, then try it out during school experience, and finally return to the community in which CKT was initially discussed and reflect on the way they had used it. Drawing on previous literature on belief change, this structure is highly likely to have affected how my PSTs perceived CKT.

In addition, coding of the data revealed that my PSTs found CKT to be relevant to their experience, accessible in its language and categorised differently to other theories that they had encountered. I was initially struck by how my PSTs' interpretations of CKT seemed subtly different to my interpretation of CKT. However, through the process of the research I developed a strong appreciation of the power of CKT being interpreted in a range of ways by PSTs, allowing them to take ownership of the theory and utilise it in the best way for themselves. In contrast to Thomas (1997), who argued that if teacher educators sanction multiple meanings for theory we are in danger of theory losing its usefulness in education, I suggest that a future point of discussion should be around whether it matters how PSTs interpret theory as long as they find it valuable for their practice; perhaps linking to ideas of personal theories and private theories (e.g., Korthagen & Lagerwerf, 1996). This may also of course re-open a discussion around what 'theory' in education actually is. Perhaps, under a different definition, CKT should not be considered a 'theory'.

The data also revealed that CKT was being interpreted in two distinct ways: as a 'tool' or as a 'source of enlightenment'. This distinction mirrors ideas from Eraut (2003) of 'knowledge for action' as opposed to 'knowledge for understanding'. I propose that these themes could be used to more deeply analyse how perceptions of theory may evolve over time, potentially requiring that PSTs experience a 'state of perplexity' that is resolved through theory as 'knowledge for understanding' before knowledge of that theory can become 'knowledge for (future) action'.

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