A Talk Framework for Primary Problem Solving

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Part-time postgraduate primary student teachers at York St John University are currently taking part in a pilot project exploring how digital audio recordings may provide opportunities to engage in closer consideration of and reflection on their mathematical problem solving performance. The project considers how thinking aloud, supported by digital audio recording may support student teachers' learning and levels of confidence in teaching primary problem solving. Having produced digital recordings of problem solving activities within university-based taught sessions, participants are given their digital recordings to listen to and analyse using a 'talk framework' in a stimulated recall situation. This framework includes the proposed categories of 'exploratory transformative' and 'exploratory encoding'. While initial findings suggest the very process of audio recording and the associated verbalisation may adversely impact upon problem solving performance, stimulated recall provides potentially valuable opportunities to reflect upon learning.

Keywords: digital audio; exploratory talk; PGCE; primary mathematics; problem solving; talk framework; thinking aloud; verbalisation.

Introduction

The aim of this PhD pilot project with part-time primary PGCE students at York St John University is to explore the ways in which digital audio devices (such as Livescribe pens) may support student teachers' learning and levels of confidence within primary problem solving. The project was, in part, inspired by early feedback from incoming trainees suggesting limited confidence in the teaching of problem solving. While questionnaires completed by participants (see below) may suggest a stronger level of confidence than anecdotally expressed, the pilot to date has illustrated a mismatch between perception and actuality that highlights issues surrounding the "transfer [of knowledge]…to new settings and events" (Bransford 2000, 19) although this may potentially be an unintended side-effect of the verbalisation required by this project.

Collaborative Thinking Aloud as a model for the classroom

The project encourages groups of student teachers to think aloud whilst engaging in primary mathematics problem solving activities, with their verbal contributions recorded using digital audio recorders. Collaborative problem solving of this kind was, in part, chosen as a focus due to its potential for modelling effective practice in the primary classroom. Mercer (1995, 1), for example, states that "creative problem-solving…[is] rarely, if ever [a] truly individual affair" while Price (2000, 52) suggests that "allowing…children to record informally and to discuss and negotiate meaning can encourage both understanding of the mathematics and understanding of its recording". Livescribe audio recorders allow for written jottings and working to be 'attached' to the appropriate sound/speech (the audio recorder is contained within the pen itself; specially designed paper allows for the replay of the audio relating to precise notes). Follow-up stimulated recall sessions, supported by a talk framework inspired by the work of Mercer (1995) and augmented by Hošpesová and Novotná's (2009) problem solving framework, are then designed to provide opportunities for reflection on the strategies employed to solve the problems, strategies that may then be taken forward by the student teachers for use in their own classrooms. Two pilot problem solving recording activities have now been carried out, with some positive indications already evident.

> I think [it did help listening back to the recording], because...I was very aware when we left that I made very little contribution because...I always seem to be chasing the tail of the people that I'm working with...trying to figure out how their brains are working through the problems as opposed to my brain working through the problem that's in front of me. (Stimulated recall transcript, October 2011)

Rationale for working with part-time primary PGCE students and initial confidence ratings

This initial work was conducted with two groups of six volunteers, across two part-time primary PGCE teaching groups. Qualifying as teachers within seventeen months, the part-time cohort was chosen in part due to the constraints presented by their limited face-to-face contact time at the university. With hour and a half maths sessions, sometimes several weeks apart, the exploitation of the VLE (and other technologies) to support learning and communication amongst peers between sessions was already a priority for tutors. Given that a number of this cohort have been away from education for some years, with the vast majority being mature students with limited recent mathematics experience (indeed, none of the participants in the pilot study have studied mathematics beyond A level), additional support between sessions for this specific group becomes more clearly beneficial to their development as effective teachers of mathematics. The problems chosen for recording were taken from the Primary National Strategy problem solving pack (DfES 2004) - material with which the students were already familiar. They, perhaps unsurprisingly, indicated a high degree of confidence in answering them with 83% of the participants stating that they were 'very confident' working out the answer to at least one of the three questions shown to them.

Confidence in Primary Mathematics

Issues surrounding teachers' perceptions of and confidence in teaching primary mathematics have long been of concern. The recent Williams Review of early years and primary maths teaching (2008, 3) stresses that "the United Kingdom is one of the few advanced nations where it is socially acceptable - fashionable, even - to profess an inability to cope with the subject", and this is borne out to an extent by the initial comments from the part-time group studied here:

> Maths has not been a part of my daily life for over six years, which creates an amount of apprehension at the prospect of teaching maths even at primary school level, as the challenges faced to raise the standards of achievements...are ever increasing. (Student teacher interviews, 2010)

Notions of confidence and motivation link to ideas of self-efficacy as discussed by Tschannen-Moran, Hoy and Hoy (1998) and Bandura (1997). People's beliefs "about their capacity to perform at a given level of attainment" may "influence how much effort [they] put forth [and] how they will persist in the face of obstacles" (Bandura 1997, cited in Tschannen-Moran, Hoy and Hoy 1998, 2). Perhaps notably, even with the less than positive comments above regarding mathematics as a whole, none of the participants in the study rated their overall confidence in maths as 'weak' at the beginning of the project. Over half (58%), however, chose to ascribe themselves to the penultimate confidence rating and, of those who rated themselves as 1 (strong) on the four-point scale (only two individuals), neither rated themselves higher than 3 for either 'teaching maths' or 'explaining strategies to help others solve mathematical problems'. Indeed, none of the participants in the pilot rated themselves as strong in either of these latter two areas. This, then, strengthens the rationale for a focus on explanations within the problem solving activities undertaken

The notion of using students' own analysis of their own responses to inform their later work in the classroom seems to fit well with Nunes and McPherson's (2007, 19) observation that "learners must acquire knowledge in ways that will help them use it in similar situations in the future…".. Whether this particular technology is the most appropriate way in which to achieve this central aim is to be determined, as is the extent to which the very presence of recording devices impacts upon the problem solving performance of the students. One student, within the stimulated recall, made the point that "I think we're all conscious of the task and the recorders but there's an argument that the more you do this task, the less of an impact this recording will have [in terms of "putting off" or distracting participants from the task being undertaken]".

Think-aloud protocols

Think-aloud protocols provide an opportunity to "explicat[e] domain specific knowledge underlying human performance" (Cooke 1999, 479). Vermersch (2009, 21) argues that such elicitation of knowledge requires "document[ation] of the subjective dimension" and therefore research methodologies that gather data based on introspection. Digital audio, supported by stimulated recall, in this instance is designed to allow for such introspection.

Mercer's (1995) talk framework, concerned as it is with effective collaborative work, proposes the categories of 'cumulative', 'disputational' and 'exploratory' talk (the definitions form the basis of figure 1 below). The framework does not concern itself with mathematical problem solving although the National Teacher Research panel study detailed by Seal (2006) makes a number of observations relating to the importance of exploratory talk in supporting collaborative learning that have been very influential on this pilot and demonstrate the application of Mercer's (1995) framework to the primary mathematics classroom. Of particular note are the stated need for "ground rules" and participants providing "reasons for what…[they]…say" (Seal 2006) that connect with the types of verbalisation detailed by Ericcson and Simon (1993).

Ericsson and Simon (1993) posit three different kinds of verbalisation, building from 'type I' to 'type III'; each type potentially impacting on the problem solving performance of the participants and so, therefore, requiring careful consideration. Robertson (2001, 13) describes 'type I' as "direct verbalisations…where subjects simply say out loud what their inner voice is 'saying'." This, Robertson (2001) states, is arguably less likely to 'interfere' with the processing of the problem in hand and is particularly important from the perspective of avoiding "invalidity due to disturbance of the cognitive process" (van Someren, Barnard and Sandberg 1994, 32). It does not, however, provide “reasons for what…[they]…say” (Seal 2006). ‘Type III’, at the other end of the scale, requires verbal descriptions of *all* that the participant is conscious of whilst engaged in the task, with the consequent risk that this will frustrate actual work on the task in hand. Montague and Applegate (1993) highlight that there is a need for both demonstration and practice in thinking aloud and this was important to the pilot project - participants were therefore asked to verbalise as much of what they were thinking as was necessary for the listener to understand what was being done, bearing in mind what was being captured by the Livescribe pens (i.e. all relevant jottings). Therefore, the movement of resources (multilink cubes etc.) would be described; ultimately, and frustratingly, participants found it hard to do this at the same time as concentrating on the thread of their conversation.

This was, however, the very point of the stimulated recall opportunity. Think-aloud protocols alone, regardless of the type of verbalisation encouraged from the participants (Ericsson and Simon 1993) are arguably unlikely to capture *all* that the participants might require to better understand the effectiveness of their strategies.

A potential talk and problem solving framework - connections between Mercer (1995) and Hošpesová and Novotná (2009)

For the purposes of this work, a pro forma was provided to structure this recall, merging Mercer’s (1995) talk framework the problem solving framework of Hošpesová and Novotná (2009). Following Seal’s (2006) consideration of the importance of exploratory talk, there was an attempt to provide a distinction between exploratory talk that utilised analogy and that which restated or rephrased the problem in mathematical terms.

Cumulative	**Exploratory Encoding**	**Exploratory Transformative**	**Disputational**
Building on contributions, adding “new” information (albeit in an “encoding” rather than “transformative” sense)...in a mutually supportive, uncritical way; constructing shared knowledge and understanding	*“Grasping the assignment” in such a way as to be able to restate the problem (in different words) or use analogy to clarify it to other members of the group (i.e. “mutually understandable language” that “encourages cumulative discussion”). Relevant information is offered for joint consideration, in **non-mathematical form** Proposals may be challenged and counter-challenged, but if so reasons are given and alternatives are offered.*	*Restating the question in mathematical terms (“Translating into the language of maths”) and consequently encouraging cumulative discussion. Relevant information is offered for joint consideration, **in mathematical*** form (i.e. identifying operations required but not explicitly stated within the original question). Proposals *may be challenged and counter-challenged, but if so reasons are given and alternatives are offered. Agreement is sought as a basis for joint progress.*	*An unwillingness to take on the other person’s point of view, and the consistent reassertion of one’s own. In its most archetypal form, it consists of ‘yes it is—no it isn’t’ exchanges, commands and parallel assertions.*

Figure 1: Pilot project problem solving pro forma

In the event, after the recordings had been produced, the participants were given transcriptions of their problem solving recordings. Having listened to their collective and individual responses, students were asked to consider their contributions according to the framework.

Initial results of pilot

Within this pilot, it was clear that, as indicated above, there was some mismatch between students’ perception of their problem solving confidence/ability and the actuality. Despite choosing questions from the Primary National Strategy pack (DfES 2004) that closely mirrored the problems included in the initial questionnaire, parallels and connections (‘exploratory encoding’) had often not been noticed -

seemingly sometimes due to the very presence of the digital audio recorder (and associated talk protocol) which, some students claimed, impacted on their performance. ("'…Well, we knew that we *had* to discuss it in this way..."). Some began speaking *before* they had fully considered the problem for themselves. ("I would have preferred to have had time on my own to look at it first and then come into it because...solutions started being talked through before I was at that point.") This indicates that, however important talk protocols may be, additional 'ground rules' are required before beginning a task of this kind. The same issues may well have impacted upon the use of the Livescribe pens (i.e. making jottings because they felt they 'had' to) but, in fact, the presence of the notes often provided evidence of exploratory contributions (three digit combinations, for example, for the problem discussed below) that would not otherwise have been evident. One thing they did *not* help with, however, was recording the exploratory use of resources which, when not verbally described clearly, was almost impossible for group members to recall ("it was the minute we had the counters, the minute we had something physical to move, it was just difficult to record").

One of the two problems undertaken (making as many three digit numbers as possible with 25 beads on one abacus) was quickly identified as being similar to a previous problem encountered ("This is like one of the problems we did last week where after a certain number, you have to...you have..yeah...") but so much was left unsaid within the recording that the rest of the group did not pick up on the meaning. It was only in the stimulated recall, demonstrating the usefulness of the exercise, that the connection became evident to the group. It is possible (as with the example above) that the contributions of other members of the group (some of whom were at cross-purposes) were 'muddying the waters' here.

> I'm really desperately trying to think [why it took so long to come to an answer] 'cos you knew reading through this [the transcript]...why did we make it so difficult? It's not difficult, is it? [Murmur of agreement] Erm...I can only think I was trying to follow someone else's train of thought... (Stimulated recall transcript, October 2011)

Conclusion

Although this project is not concerned with the frequency of cumulative, exploratory and disputational talk within the recordings, it is notable (and the students themselves commented on this) that there were very few instances of disputational talk, even when the stimulated recall reveals that not all fully understood the contributions of their fellow group members. Where this *did* occur, it was prompted by a failure on the part of group members to operate collaboratively ("I was starting to feel an increasing frustration at the sense that there was this one little group *here* and there was one little group *here*…each trying to sort out the problem…" [and failing to communicate with each other], strongly suggesting that the initial protocols need to be more clearly established, and if exploratory talk is to be encouraged, then it needs to be more clearly modelled prior to any future repeat of this exercise.

If "metacognitive practices…[do]…increase the degree to which students transfer to new settings and events" (Bransford 2000, 19), it may be that stimulated recall exercises of this kind, aided by technologies such as digital audio, have the potential to ameliorate the failure to transfer knowledge from one situation to another (as seems to have happened here - if it was not, in fact, the recording exercise in the first place that obstructed the 'exploratory encoding' or grasping of the assignment by encouraging students to behave in an 'unnatural' fashion). It is clear that there is still work to be done on both the talk protocol employed and the modelling/briefing students receive prior to engaging in the activity in order to more fully encourage and ultimately analyse the potentially productive exploratory talk emerging from such collaborative work.

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