Engaging students with pre-recorded "live" reflections on problem-solving: potential applications for "Livescribe" pen technology

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Building on the author's PhD work with part time postgraduate (PGCE) primary student teachers, this paper considers the potential application of *Livescribe* pen technology to facilitate/support reflection on collaborative mathematical problem solving, allowing opportunities for participants to engage in 'live' reflection on their 'free' problem solving performance in order to elicit reasoning/effective strategies and thereby inform their future practice. With recorded (group) thinking aloud, followed and supplemented by a stimulated recall/task-based interview opportunity and associated problem solving/talk framework, participants are encouraged to articulate their problem solving strategies, experiences and understanding with the benefit of potentially reduced influence from the researcher. The risk of think-aloud protocols impacting negatively on problem solving performance is arguably reduced by the use of a technology that allows the 'replay' of participants' workings/jottings alongside their verbal contributions.

Keywords: digital audio; thinking aloud; primary; PGCE; problem solving; stimulated recall.

Introduction

As discussed in Hickman (2011), the overarching focus of this project is on the ways in which digital audio can support student teachers' learning and levels of confidence in teaching primary mathematics (specifically problem solving) to their own pupils. To this end, and utilising a think-aloud protocol (T-AP) informed by the work of Ericsson and Simon (1993), their verbal contributions during collaborative problem solving activities (taken from Primary National Strategies materials) are recorded using digital audio recorders with the recordings subsequently played back to them in stimulated recall interviews (SRIs). The SRIs allow opportunities for participants to reflect upon the different types of verbal contributions made (in line with Mercer's (1995) talk framework i.e. identifying 'exploratory' and 'cumulative' contributions and considering their impact upon the group's 'success' at solving the given problem) as they 'relive'/replay their original work. They also arguably provide opportunities for the student teachers to identify effective problem solving strategies to take forward into their classroom practice, although this is not a major consideration of the current iteration of this work (which is not directly concerned with following the participants into the classroom as it considers student teachers' perceptions of their levels of confidence in teaching primary problem solving).

Both T-AP and SRI allow opportunities for participants to reflect upon their mathematical problem solving performance – the former *during* a task 'in the moment' in a self-directed fashion; the latter at some point afterwards, although with the caveat that, as recommended by Fox-Turnball (2009, 206) it "should occur as

soon as possible after the task is completed". Both Ericsson and Simon (1993) and Robertson (2001) comment upon the different 'levels'/types of thinking aloud that are possible, with greater amounts of verbalisation potentially causing greater disruption to mathematical thinking and performance. This provides a rationale for avoiding excessive verbalisation during the task and exploring opportunities for post-task reflection via SRI. The *Livescribe* pen (detailed below) has supported the combination of both methodologies to allow for verbalisation of the strategies employed during a group problem solving event to be 'revisited' within SRI and even potentially built upon, with some new learning arguably taking place as a result of this 'live' reflection on pre-recorded work. Such a concentration on student teachers' verbal contributions fits well with Duval's (2006, 104) point that "research [of this kind]…must be based on what students do really by themselves, on their productions, on their voices" and in the case of this project, the students' reflection affords the potential for them to learn about their own learning (in a metacognitive sense) from their own voices.

In this way, the SRI provides the opportunity to identify and/or reconsider participants' "knowledge" of their problem solving strategies. This process was, in part, influenced and informed by Goldin's (1997, 41) task based interviews which allow researchers "to observe and draw inferences from mathematical behavior". This four stage exploration begins with 'free' problem solving "with sufficient time… [for response]… and only non-directive follow-up questions" and culminates in "exploratory (metacognitive) questions (e.g., "Do you think you could explain how you thought about the problem?")" (45). The initial recording with think-aloud protocol and *Livescribe* pen affords the opportunity for 'free' problem solving; Goldin's (1997) succeeding stages are evident within the SRI that follows.

Livescribe pens

The brand name *Livescribe* refers to a digital pen with built-in digital audio recorder and camera which tracks the user's writing across special proprietary paper, recording both the marks made and any speech/utterances produced during the writing – providing the user has remembered to press 'record', of course!. While the pen can be used as an ordinary pen on regular paper, any writing produced will not be attached to audio recordings made (indeed, the pen is not able to record sound without 'tapping' the record icon on the proprietary paper so its usefulness with ordinary paper is singularly reduced) and replay will not be possible.

Recordings can be listened back to in one of two ways: either by tapping any written word on the note paper to listen back to the exact word/s said when the word was being written or by connecting the pen, via USB, to a computer and using the '*Livescribe* desktop' to upload the contents of the pen for replay on screen. Having done this, it is then possible to 'play back' an entire page of work (or more) with associated audio. The writing appears, in real time, on a virtual version of the original paper on the computer screen (with the sound coming through the more powerful computer speakers instead of the very small speaker contained in the pen). Either one of these methods would be able to facilitate recall, should it be required. In the pilot work for this project, it quickly became clear that the latter approach, when working on group problem solving and therefore group recall, was preferable as the whole group could more easily both see and hear the replay of their work. Within the SRI, the group are able to hear their original spoken contributions and consider how these relate to specific written symbols and working; this has, indeed, prompted some interesting and useful observations:

> 'I had three columns written on the paper and, like XXX was saying, that the image on the top of the sheet, wasn't it, with the three…?'
>
> 'Yeah, and so I've gone…right…***nine***…that would that…whatever…and that, whatever…and then we went systematically down and then it occurred to me, why don't we start with nine?' (Stimulated recall transcript)

The above extract from a recall session illustrates the way in which the recording informed the response given – the second respondent identified their first contribution of "nine" and their resultant attempt to work "systematically" through the problem from the 'animated jottings' provided by *Livescribe*. If students had listened back solely to their verbal contributions, the strategy employed to attack this particular problem ('*make as many three digit numbers as possible with 25 beads on one abacus*') would not have been clear – indeed, this particular individual's one and only verbal contribution at this point in the recording was the word "nine". Even with the T-AP employed strongly encouraging participants to explain their reasoning, such was the enthusiasm of the group (with overlapping speech and much in the way of 'unfinished' thought) that the student had been unable to add to their statement, 'swept away' by contributions from their peers.

> 'So it comes down to what you can't see…in the audio…there was an attempt to try to verbalise this, I know…I tried to tell someone, can you just say out loud…?'(Stimulated recall transcript)

As seen above, participants attempted to 'hold each other to task' by indicating where things needed to be (more effectively) verbalised; they were also able to indirectly reflect upon the inadequacies of audio recording/T-AP alone as a method for capturing their contributions (and this will, indeed, be used to inform further iterations of the work). Within the *Livescribe* SRIs, the audio supported notes often provided evidence of exploratory contributions that would not otherwise have been evident (such as proposing nine as an appropriate, systematic place to begin when addressing the problem above). To an extent, then, it could be argued that this 'makes up for' and even potentially enhances the quality of the participants' original mathematical discussion.

> So, we've got all the combinations of 9. 8 and 7…so you've got 3 9s in each, 9 appears three times in each column, 8 appears twice…
>
> And that must be because [of] the number bonds in 25…something to do with number bonds… ('Beads' Digital Audio transcript)

In the extract above, participants have already gone some way towards solving the 'beads' problem just eight minutes into the recording; that they continued their discussion for a *further* eight minutes illustrates their level of uncertainty. The *Livescribe*-supported SRI allowed them to revisit this and actually confirm their original thoughts.

> I'm really desperately trying to think 'cos you knew reading through this...why did we make it so difficult? It's not difficult, is it? [Murmur of agreement] (Stimulated recall transcript)

In some respects, the 'live' reflection within the SRI enables a 'second go' at thinking aloud and, as will be further discussed below, this additional layer of thinking aloud brings aspects to participants' attention that were not evident when first tackling the problem.

Contrasting digital audio recorders and Livescribe pens

As indicated above, initial pilot work involved 'traditional' digital audio recorders, albeit supported by transcripts of the participants' problem solving work and their original jottings within the original SRI. This led, as will be discussed below, to some confusion amongst the students in identifying which of the written jottings matched with their verbal comments and, indeed, one problem which quickly became apparent was that the discussion in the SRI became over-focused on these more 'technical' issues.

Other technologies such as tablet computers may provide some of the advantages of the *Livescribe* pen in that they can allow the recording of audio in conjunction with written notes (also affording the playback of such recordings alongside jottings), as indicated by Weibel et al. (2011). However, there are advantages to paper-based working that fit well with this project and its postgraduate student teacher participants: paper is "portable, cheap and robust" and it is "much more convenient to scan through a book than to browse a digital document" (Weibel et al. 2011, 258). This, in part, informs the use of *Livescribe* over tablet computers or other similar technologies in this work. In addition, it is arguably equally beneficial to employ a technology that requires less in the way of formal briefing or training, given the relative simplicity of the pens compared to other technologies, when working with student teachers with varied levels of ICT experience and whose confidence in and contribution to problem solving tasks is the primary concern of the work. Although the intention of the project was always to utilise *both* the T-AP and SRI methodologies (which, of course, could have stood alone as independent methods for capturing data on domain specific problem solving), participants were able to identify their exploratory comments more effectively within the *Livescribe* supported SRI than those produced by digital audio alone. It is also clear that the import of their original exploratory statements had not been recognised via the T-AP alone due to their listening to each other's contributions (as would be expected in group problem solving opportunities), the level of concentration required on own verbal contributions and, indeed, their awareness of being recorded in the first place.

Beyond just 'missing' exploratory contributions made in the original problem solving event, participants had also missed connections with previous problems encountered and successfully solved. The framework proposed in Hickman (2011) is informed by Mercer (1995), Hošpesová and Novotná (2009) and Seal's (2006) identification of the importance of exploratory talk. For the purposes of this project, 'exploratory' contributions have been split up into those that restate the problem by using analogy to clarify it to other members of the group and those that restate it in mathematical form (i.e. identifying operations required that were not explicitly stated in the original question). Both categories are arguably assisted by an appreciation of 'similar' problems (i.e. a problem is seen to be 'like' another that had previously been encountered); with the T-AP alone, however, contributions of this kind were not much in evidence. For example, in the SRI (but not in the T-AP) of the abacus problem, participants noted that they had, in fact, been presented with a problem similar to one that had previously been encountered (indeed, the problem had been chosen for this reason) – they had simply failed to notice this on first encounter. Watching their tabulation of the *Beads* problem on the screen in consort with their verbal offerings had made this clearer to them. Therefore, the *Livescribe* supported SRI afforded students the opportunity to make connections, from their original contributions and

working, that had not been explicitly identified in the original problem solving session.

One contention of this project is, then, that *Livescribe* pen technology is better able than the more 'traditional' digital audio recorders to afford participants the opportunity to revisit their actions *in* the moment whilst standing *outside* the moment. The 'replaying' of their written notes alongside (essentially 'in time with') their original verbal contributions potentially also provides a stronger prompt for recall and ultimately reflection than the more typically employed (in SRI) video and audio technologies which do not so strongly connect the written with the spoken.

Conclusion

The 'unfinished' nature of much of the participants' verbalised thought in the T-AP recordings produced to date was caused in part by the attempt to reduce the impact of the protocol on their problem solving performance by limiting the amount of thinking aloud that actually had to be articulated. This reflected Ericsson and Simon's (1993) comments about the degree to which more 'extreme' verbalisations of thoughts, moves and actions will ultimately impact on the mathematics. A higher level of verbalisation could potentially have reduced the number of 'unfinished' thoughts but ultimately would not have prevented other issues impacting upon these recordings, including interruptions from other members of the group that inadvertently cut short their peers' speech. It is, therefore, perhaps unsurprising that such thought was not always effectively built upon (in Mercer's (1995) 'cumulative' sense) within the original problem solving opportunities. Participants' attention was split between the demands of the problem set, the need to solve this with/alongside their colleagues (which, of course, is not itself without problems due to the risks of 'exposing' mathematical uncertainties in front of peers) *and* the 'artificial' situation of being audio recorded/having to think aloud whilst engaging in this work. We suggest that the *Livescribe*-supported SRI reduced the impact of these factors by providing a valuable opportunity for them to clarify what had originally been propounded both by themselves and their peers and revisit their learning in a way that fits well with Polya's (1957) concept of 'looking back' at problem solving work. It allows them to concern themselves less with the think-aloud protocol during the original recording, even omit details that would be seriously 'missed' if recorded by conventional digital audio recorders, as a combination of spoken and written material is employed within the SRI to prompt their recall. Indeed, their SRI contributions to date indicate that the technology allows them to identify *for themselves* especially productive/beneficial contributions made, that may not have been recognised as such by observers, and this again fits well with the four stage exploration of Goldin's (1997) task-based interviews. Some refinement to the T-AP utilised to underpin this work is almost certainly required to address some of the issues encountered by groups such as unintentional interruptions. More also arguably needs to be done to effectively 'capture' participants' resource use whilst solving problems (although an effective T-AP that ensured participants articulated clearly their choice of appropriate resources and thinking behind this would prevent this being a major problem). However, the *Livescribe* technology itself has shown some promise in prompting productive responses that encourage deeper exploration and even exploratory talk (Mercer, 1995) and this, when enhanced further, may be of significant benefit to future classroom practitioners.

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This research article looked the effectiveness of an assistive technology tool, the Livescribe Pen (LSP), with an elementary student identified with dyslexia over a one-year study with teachers, parent, and child. While the LSP was primarily utilized for curriculum accessibility and an audio tool to promote academic independence, the study's findings reveal its impact as an.Â Harper, Kelly A; Kurtzworth-Keen, Kristin; Marable, Michele A. Assistive Technology for Students with Learning Disabilities: A Glimpse of the Livescribe Pen and Its Impact on Homework Completion. Education and Information Technologies, 2017, Vol. 22(5), p.2471-2483.