Northumbria Research Link

Enacting Darby's (2005) Notion of Engaging Pedagogy in Primary Science

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ABSTRACT

The aim of this study was to evaluate the use of peer review as a formative assessment tool to enable pre-service teachers (PST's) to explicitly demonstrate links between the theoretical component underpinning their primary science specialist course – Darby's (2005) notion of engaging science - and its enactment in professional practice. This study outlines how PST's were supported to operationalise their subject matter knowledge (SMK) and knowledge of formative assessment to create specialist pedagogical content knowledge (sPCK) using experiential, collaborative and dialogic models of teaching. The use of feedback as feedforward (Hounsell, 2008; Nicol, 2010) was observed to support PST's construction of discipline-specific knowledge, knowledge elaboration and their development as self-regulated learners capable of meaning making.

BACKGROUND

Science for Primary Teaching 4 (Science 4) is a level 3, 20-credit primary science specialist module that PST's enrolled on the BA (Honours) in Primary Education at Durham University can select as one option from a choice of four (English, mathematics, science and Computing and ICT) leading to dissertation study at the end of Year 2. This specialist module, originally designed by Professor Lynn and Professor Douglas Newton, is predicated upon Darby's (2005) notion of engaging science pedagogy that differentiates two distinct dimensions, instructional and relational pedagogy, through which PST's can begin to support pupils' development of scientific understanding.

Within the instructional dimension, Darby identifies the language of responsive teaching as the key facilitation device through which teachers make their own scientific subject matter knowledge accessible to pupils via dialogic strategies including explanation and clarification. Within the relational dimension she identifies a teacher's enthusiasm for the subject and ability to create a comfortable and supportive learning environment as key to engaging pupils' interest. My purpose was to develop a strategy to facilitate PST's enactment of Darby's (2005) notion of engaging pedagogy in practice using models of teaching that align with constructivist pedagogies in recognition that knowledge is a constantly evolving and dynamic construct, developing in response to personal reflection upon experience. For example, at the beginning of each session a variety of elicitation strategies are used to capture PST's existing knowledge to identify possible misconceptions and to establish a baseline from which to target questioning and to develop investigations. These strategies include construction of pre- and post-activity concept maps, (Novak, 2010), completion of true/false SMK quizzes, placement of statements on an agree/disagree/unsure continuum and discussions using concept

cartoons (Naylor et al, 2000) enabling comparisons to be made between learners' understanding before and after practical inquiries.

INTERVENTION DESIGN: TEACHING-FEEDBACK LOOP

I designed a seven-step intervention using peer-review to generate feedback for use as 'feedforward' to inform the design of group posters that explained how PST's had enacted Darby's (2005) principles of engaging pedagogy by problematising and transforming SMK into sPCK drawing on practical investigations, experiential, collaborative and dialogic models of teaching including the use of analogies, role-play, exploratory, cumulative and disputational discussion. By facilitating collaborative peer review I aimed to enable exploratory conversations about learning to take place between PST's and between tutor and PST's.

PRE-COURSE TASK

1. A key reading, Darby's (2005) was posted onto the Durham University On-line (DUO) learning platform. In preparation for the first Science 4 session PST's were asked to deconstruct and then summarise this article using a directed reading analysis template and an instruction to draw on their prior learning of their Year 2 Research Methods course, studied the previous semester, to identify the purpose of Darby's research, her research question and what methods she used to gather the evidence to inform her conclusions.

WEEK 1 PEER REVIEW TASK 1

2. At the first science session PST's were asked to share and peer review their individual summaries of Darby's (2005) article in groups of four. This provided each trainee with an opportunity to participate in a feedback discourse opportunity in which they supported one another's understanding of the article through peer scaffolding, exploratory and cumulative dialogue.
3. PST's edited summaries of Darby's (2005) article were then used as feed forward to inform the construction of spoke and chain concept maps to identify the key features of instructional and relational pedagogy. These maps were shared with the whole group and then peer reviewed stored to inform Step 5 (below).

WEEK 3 PEER REVIEW TASK 2

4. PST's reviewed their group concept maps prior to participating in a primary science workshop that focused on electricity (DfE, 2013) and included a carousel of practical science investigations designed to problematize SMK and develop sPCK using inquiry as a 'way of doing' science. This approach allowed them to raise questions and to test out their ideas to support deconstruction of previously held misconceptions. During the workshop PST's engaged with scientific phenomena via:

   a. elicitation and capture of prior knowledge of electricity using concept mapping.
   b. constructing simple circuits.
   c. adding components to series circuits and observing, measuring and recording effects.
   d. testing properties of materials using circuits: insulation and conductivity.
   e. generating static electricity.
   f. demonstrating current using analogies: tennis balls, teddy bears.
   g. demonstrating instantaneous flow of current: skipping rope analogy.
   h. revision of Darby's engaging pedagogy concept maps adding new knowledge and insights (revisioning, reconceptualisation – assimilation and accommodation).
   i. application of knowledge in a STEM problem-solving task to constructing a bedside lamp for Little Bear.

5. PST's were then invited to construct group posters to explain how they had enacted Darby's principles of engaging pedagogy to construct new SMK by problematising and transforming SMK into sPCK. They were encouraged to critically reflect on the practical investigations they had just carried out and to draw on their revised concept maps created in Step 3 and revised in Step 4 (h).

EVALUATING THE POSTERS

6. The groups were provided with a checklist of success criteria (Figure 1) and (Photograph 1 Peer Review Generating Dialogue) to use to analyse the posters – this was an analytical framework designed in accordance with Darby's (2005) two dimensions of engaging pedagogy and Kalyuga's (2009: 402) elements of knowledge elaboration, to provide success criteria against which PST's could begin to peer review the posters (Table I). PST'S were required to place a cross in each cell of the framework to indicate whether each group of PST's had included these elements in their posters. PST's were invited to pose questions

and comments relating to the images, textual comments, diagrams and representations included on each poster, these were captured on post-it-notes and placed on the posters during the peer review process (Figure 1).

Figure 1 Success Criteria: An Analytical Framework to Support Peer Review of Group Posters: (After Darby, 2005 and Kalyuga, 2009)

Knowledge elaboration element		Group 1	Group 2	Group 3	Group 4
Categorization activities:	Organizing concepts	X	X	X	X
	Sequencing ideas	X	X	X	X
Making connections	Integrating prior knowledge	X	X	X	X
	Integrating novel ideas				
Synthesis	Restructuring information (misconceptions)	X	X	X	X
	Construction of new knowledge SMK; sPCK	X	X	X	X
Instructional Pedagogy	Instructional dialogue: questioning, explanation, clarification. Generating Interest Supporting Understanding	X X X X X	X X	X X X X	X X X
Relational Pedagogy	Enthusiasm (Passion) Atmosphere (Comfort) Support	X	X	X	X

7. PST's reflected on how effective the intervention had been in enabling them to enact Darby's notion of engaging pedagogy and in raising their awareness of their own metacognition.

RESULTS AND DISCUSSION

Four groups of PST's worked collaboratively to construct posters to show how they had enacted Darby's (2005) principles of engaging pedagogy during a workshop on electricity.

Group 1 developed the metaphor of a working circuit to represent their learning journey using real components to represent isolated and unconnected units of prior knowledge about electricity. (Photograph 2 Poster 1 Using the metaphor of an electrical circuit to demonstrate enactment of Darby's (2005) notion of engaging pedagogy). Textual comments, annotated diagrams, and components were used to convey the group's negotiated understanding of abstract scientific phenomena. This poster demonstrated that when units of prior knowledge are not meaningfully connected no current can flow – understanding is insecure because of embedded misconceptions. Connections are made between units of knowledge when PST's assume the role of teacher-as-learner, and are free to engage in practical investigations to test out their own ideas and to discuss their observations. Furthermore, this metaphor was sustained through the use of a battery to represent pre- and post- session subject knowledge elicited using concept maps. At the start of the session when there were no connections the battery (SMK) was inactive; at the end of the session when all connections were in place the battery was fully functional, current flowed, the bulb lit up because SMK was fully operationalized. Their textual comments explained how analogies were used to bridge these gap between prior knowledge including naïve conceptions (misconceptions) and new understanding of abstract phenomena generated through practical inquiries in which they tested out their ideas while constructing and observing circuits.

Diagrams and comments explained how models of teaching (experiential, dialogic and collaborative) were also used to link prior knowledge with new knowledge by providing direct experience through investigations, enabling them to link up the parts in the circuit to facilitate the flow of current (understanding). The transfer of enthusiasm from teacher to pupil was illustrated using innovative teaching pedagogies including analogies to support the development of understanding of abstract phenomena. The role of practical work and use of terminology in context of practical activity was shown to both bridge and scaffold learners to next steps enabling progression to be demonstrated. The development of specialist PCK was illustrated through professional decision-making identifying which teaching strategies to use, for example experiential and child-led learning. During review peers commented that when Group 1 members explained and clarified the different aspects of the poster (circuit) they all felt they were building and connecting knowledge using instructional pedagogy effectively – to enact Darby's theoretical perspective in actual practice. They felt the use of this 3 -dimensional visual metaphor helped them all to 'put together' or connect knowledge to build deeper understanding.

Group 2's poster developed the metaphor of a teacher as a builder constructing a wall of knowledge brick-by-brick, concept-by-concept. PST's drew pictures of a bridge

built to secure links between prior knowledge and new understandings – representing assimilation and accommodation. This group divided their poster into halves to illustrate the two dimensions - instructional and relational – of engaging pedagogy. Elements of instructional pedagogy included an emphasis on the use of focused questions, both teacher's and pupils. Aspects of relational pedagogy included explicitly identification of a teacher's passion and enthusiasm for science, the provision of a comfortable working atmosphere, and support for individual learners as essential features but without elaboration. This poster also identified how socio-cultural learning facilitates peer dialogue. Peers requested the authors of this poster should provide more details about the practical activities that could be used to illustrate the textual comments and identified this particular poster as a good revision aid for their end of year examinations.

Group 3 developed the visual metaphor of constructing a jigsaw to represent how conceptual understanding takes place - learners build knowledge and understanding by putting together the pieces (threshold concepts) one by one to form a coherent whole. Elicitation instruments to elicit pupils' prior knowledge of circuits and electricity were identified using concept mapping. PST's identified how explicit instructional teaching strategies, using analogies enabled teachers to link prior and new knowledge for example circulating teddies, circulating tennis balls and hand-to-hand contact to illustrate the flow of negative charge through metal wires; they also used the analogy of a 'tugged skipping rope' to model the instantaneous flow of negative charge through metal wires when battery connections are made. This poster identified the usefulness of both children's and teachers' questions linked to Bloom's revised taxonomy (Anderson and Krathwohl, 2001) to initiate inquiries, to test ideas, develop higher-order thinking and build understanding – however, no examples of these questions were provided. Moreover, during review peers spotted this omission and asked for examples of Bloom's revised questions to exemplify the textual comment. This aspect of peer review was appreciated – identifying ways to improve the poster by requesting evidence or examples of greater professional knowledge elaboration. Peers also raised the issue of children investigating their own questions about phenomena – "what if they get the answers wrong?" This led to a debate about how subject knowledge is constructed, how misconceptions may develop and be deconstructed and the value of practical work in allowing pupils to test out correct and incorrect ideas.

PST's in Group 4 exemplified Darby's principles of engaging pedagogy as a concept map comprising connected textual comments and statements that were related to the development of specialist teaching pedagogies including experiential, collaborative, dialogic (questioning, discussion) and problem-solving activities. They gave a selection of practical investigations that they could carry out together with children to

co-construct knowledge. This group identified opportunities for formative assessment to feed forward into personalized learning targets for pupils to support differentiated investigations and whole class inquiries.

Each of the metaphors used in the group posters visually demonstrated how teachers can link new knowledge to prior knowledge to support the deconstruction of misconceptions and re-conceptualisation of key ideas using through investigations, analogies and role-play, constructivist teaching strategies concordant with the knowledge elaboration processes of assimilation and accommodation (Kalyuga, 2009).

This intervention enabled PST's to demonstrate the role of personal learning experiences in transforming misconceptions about electric circuits and electrical conductivity and identified key threshold concepts that constitute troublesome knowledge (Meyer and Land, 2003). For example PST's deconstructed SMK by interrogating analogies. They then had to think about how they could make this new SMK accessible to younger learners to prevent introducing misconceptions – that is to transform threshold concepts into sPCK that will make these concepts accessible to KS2 pupils by identifying key ideas around which sPCK can be developed. The use of peer review enabled PST's to reconceptualise their SMK and to problematize SMK to enable them to generate sPCK. For example, through the production of post-it-note comments placed onto the posters PST's opened up opportunities for dialogue suggesting revisions to clarify explanations that helped PST's to gain new insights supporting reconceptualization of PST's foundational knowledge bases. By doing this PST's were enacting Darby's principle of instructional pedagogy.

This is the first time I have used peer review with this group of Science 4 students and I found it a useful strategy to provide PST's with opportunities to engage in reflective thinking in-action and on action (Schon 1980). For example, PST's dialogic inquiries (raising questions to launch investigations) demonstrated that teaching knowledge bases do not exist as an entity but are constructed by individuals as they interact and engage in interpretation. PST's identified participation in the range of collaborative tasks offered as very valuable in raising their meta-cognitive self-awareness. For example, the construction of group concept maps and posters provided fora for dialogue resulting in the creation of spoke and chain concept maps to represent the integration of professional knowledge bases that demonstrate enactment of Darby's (2005) principles of engaging pedagogy, explicitly linking theory and practice. In my future practice I would use peer review to enable PST's to operationalize their SMK, sPCK and metacognition providing a forum in which they can demonstrate and explain their understanding of aspects of understanding of the theoretical perspectives that underpin their teaching and learning practices through peer-led seminar presentations as part of a more diverse range of

summative assessments. I would also re-design the framework I provided to include a focus on Bloom's revised taxonomy within the success criteria checklist, to explicitly raise their PST's awareness of the role of higher-order questioning as a tool to further pupils' investigations.

<u>CONCLUSION</u>

The peer review process resulted in posters that provided me as a lecturer with a rich source of evidence represented as visual symbols, metaphors and textual feedback to enable me to evaluate PST's understanding of threshold concepts relating to electrical circuits and PST's abilities to enact Darby's (2015) principles of engaging pedagogy. Drawing on this evidence I was able to suggest future directions for personalising learning goals – for example suggesting greater focus on the use of language – specifically questioning – as a tool to further inquiries, to elaborate SMK and to scaffold understanding. The process of peer-review was instrumental in enabling PST's to demonstrate the ways in which they had engaged with SMK - problematising and transforming it into sPCK through the use of metaphors to represent constructivist teaching and learning approaches and the recognition of inquiry as a way to test out their own ideas and reduce the possibility of developing misconceptions about phenomena that is abstract. The process of peer review encouraged PST's to engage more deeply with SMK, sPCK and theory (Darby, 2005) in order to represent the integration of these areas of knowledge in a poster. The collaborative nature of the peer review task, following practical activities, provided PST's with opportunities to think critically about knowledge and to allow them time for critical reflection to facilitate the co-construction of shared understandings in accordance with a constructivist paradigm. The use of collaborative peer review tasks could provide a potential mechanism to facilitate the integration of academically and professionally acquired knowledge bases, enabling knowledge elaboration to be demonstrated though the generation of dialogic feedback. Archer (2010) draws on a socio-constructivist paradigm to assert that the use of such dialogue between peers and between PST's and tutors enables feedback to become facilitative, enabling the reconceptualization of SMK. With respect to science such dialogic approaches are also supported by the iterative nature of inquiry as a way of building scientific understanding in which groups of PST's act as co-investigators and co-constructors of knowledge through participation in shared experiences. Learning thus becomes a dynamic and iterative process facilitated through connection with and reflection on feedback to provide feedforward that informs action-on-reflection (Wenger et al, 2002).

Peer review of the resulting posters also enabled PST's to appreciate the existence of variety in the ways their peers had responded to the teaching on the course (Marton and Säljö,1970). PST's were able to compare the different ways in which they had elaborated theoretical and professional knowledge. This intervention has demonstrated how PST's were supported to operationalise their SMK to create sPCK using experiential, collaborative and dialogic models of teaching to generate 'feedforward' to inform the design of group posters that illustrate Darby's principles of engaging pedagogy. Moreover, this particular example of peer review supported PST's deeper connection with SMK and raised their metacognitive awareness by providing PST's with a model of constructivist methodologies and peer assessment on which they can draw to inform their own repertoires of teaching, learning and formative assessment practices when working with their own pupils to develop scientific understanding. As Ofsted (2008:19) recognise:

'Good formative assessment is crucial to success […] In good science lessons, teachers ensured that pupils understood the purpose of activities and that they were closely involved in discussing their work and testing out and refining their ideas. Their good quality feedback identified what had been achieved and how improvements could be made. In doing so, they helped pupils develop more responsibility for their own learning.'

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