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Socio-Scientific Inquiry Based Learning (Ssibl): Gearing Social Action to Scientific Knowledge

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Abstract

This research arises from an EU FP7 project (Promoting Attainment of Responsible Research & Innovation in Science Education, PARRISE) designed to support teachers in promoting inquiry through socio-scientific issues. There are three features behind the SSIBL framework: an authentic question or problem with a scientific component which derives from student interest and the perceived need for change; proposed actions which address the question; and enactions which encompass processes in enabling action. SSIBL is not hierarchical and is predicated on the basis that solutions contain the seeds of new questions. In that sense it reflects Deweyan inquiry where emergent scientific knowledge is based on the need for change and action. SSIBL presents a pedagogic challenge because it problematises the epistemological boundary between normative questions on one hand and descriptive statements on the other. Another challenge is that authentic questions on socio-scientific issues do not necessarily arise spontaneously from students. Because such an approach challenges the canonical 'Vision I' approach of the science curriculum in the U.K. we were keen to identify the possibilities and challenges of implementing an approach through pre-service teachers (PSTs) in schools. We ran activities which encouraged PSTs to generate authentic questions of their own and to plan their own SSIBL activities in their practicums. We gathered questionnaire data from 72 student teachers, teaching in two practicums in 77 schools, on their experiences in teaching SSIBL and from this drew on three individual studies through a focus group format. Through descriptive analysis of the questionnaires and thematic analysis of the individual studies a picture emerged of possibilities of enactment where school science departments were open to change and not confined by performative outcomes. Where such possibilities were implemented students both learned how to carry out socio-scientific inquiries but used this knowledge to underpin their emergent scientific knowledge. Impediments to implementation ranged from fear of dealing with 'political' matters to a reluctance to challenge curriculum orthodoxy. Successful implementations were used as exemplars to enhance SSIBL teaching in schools with improved acceptance.

1. Introduction

The European Union has a broad commitment to Inquiry Based Science Education (IBSE) [1]. Inquiry-based methods have been shown to increase 'both children's interest and teachers' willingness to teach sciences' (p. 12). We are part of an EU-funded consortium, Promoting Attainment of Responsible Research & Innovation in Science Education, (PARRISE), and the particular focus of this project and accompanying research is on socio-scientific inquiry based learning using the acronym SSIBL. The project is aimed at addressing teacher professional development through ages from 5 to 19. Our project acknowledges the importance of social participation: scientific research and production should be carried out *with* and *for* society [2]. How this can be achieved presents political and structural challenges [3] through 'anchor points' that are ethically acceptable, sustainable and socially desirable (the main purposes of the EU's flagship Responsible Research & innovation (RRI)). At the heart of SSIBL, is researching a question aimed at improving local and/or global conditions, producing realisable outcomes through democratic processes, and drawing on scientific knowledge that may be recontextualised as part of this process. The inquiries should stem from the concerns and pre-

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occupations of the young participants, although we recognise that social inquiries stimulated by controversy need to incorporate a pedagogical trigger. The SSIBL model can therefore be configured as having three main features (Figure 1): an *authentic question* or problem with a scientific component which derives from student interest and the perceived need for change; proposed *actions* which address the question; and *enactions* which encompass processes in enabling action. The non-linear SSIBL model is predicated on the assumption that proposed actions raise new questions further open to inquiry and interrogation.

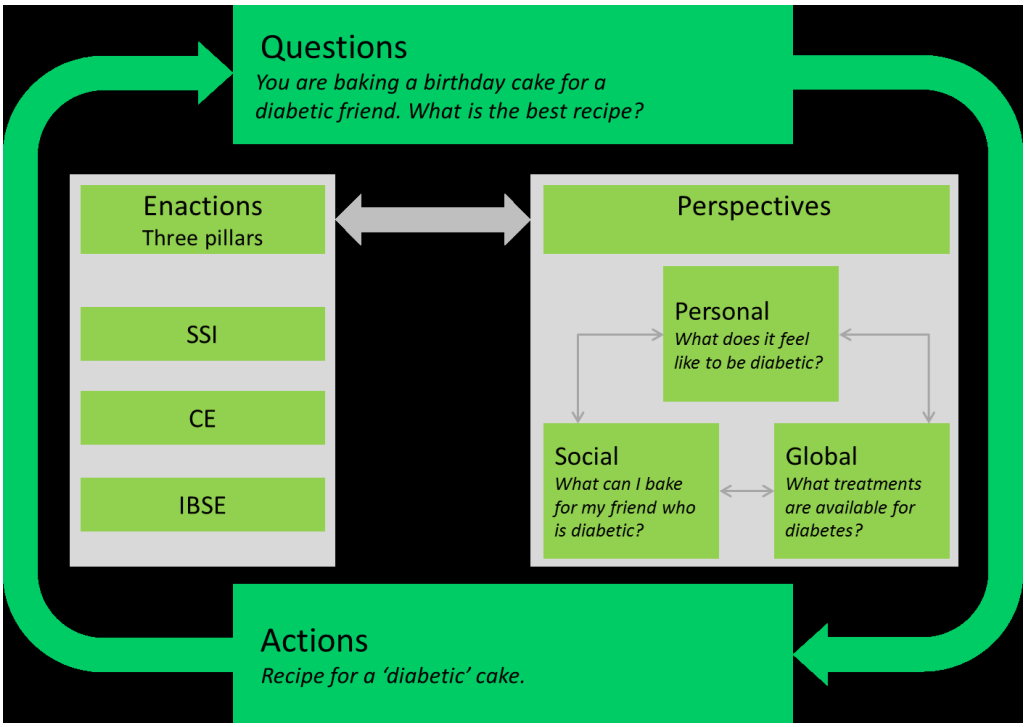

Figure 1, SSIBL model

The model is illustrated through an exemplar in which school students aged 9 and 10 propose baking a birthday cake for a diabetic friend and devise a recipe which they publish (action). In so doing the inquiry draws on three pillars/enactions of SSIBL: socio-scientific issues (SSI) – the social aspect is to consider what it is like for a young person to live with diabetes; the scientific issue involves understanding the clinical effects of diabetes and the science of baking, e.g. how raising agents work. Citizenship Education (CE) in this context incorporates collaboration, listening to each other's ideas and decision-making. IBSE, the inquiry component, involves establishing criteria and deciding on the evidence that meets the criteria. The model also incorporates perspectives at the personal, social and global level. The SSIBL model is contextualised within RRI (the black rectangle).

2. Research problem

There are a number of challenges facing the implementation of SSIBL in schools. First, most inquiry-based activities relate to substantive science content aimed at reinforcing knowledge of scientific principles, known as Vision I [4], excluding the social. Second is the problem of integrating descriptive statements associated with Vision I science with normative statements [5] and an approach that might benefit through interdisciplinarity. Third is that SSIBL can incorporate methods such as surveys, interviews, ethnographic studies not usually associated with school-based scientific inquiry. Fourth, solutions to SSIBL questions are often complex and open. Finally, and most pertinent to our study, is that inquiry learning tends not to be a high priority in a curriculum in the UK underpinned by high-stakes content-based assessment.

3.Research approach

Enthusiastic early career teachers can act as agents of change in supporting educational innovation into the teaching and learning community of practice once they feel confident in doing so. A key factor in developing confidence is the effective partnership between pre-service teachers, teacher educators and experienced science-teacher mentors in school, as constituents of a teacher-growth network [6]. In this study, pre-service teachers on an Initial Teacher Education programme in London, UK, explored the following areas:

- What are teachers perceptions of inquiry
- What opportunities and obstacles do they see in terms of SSIBL?
- How can PSTs build on inquiry in schools to develop SSIBL?

4.Research methods

In the first phase, the pre-service teachers (PSTs) questioned experienced science teachers in 77 secondary schools about notions of inquiry science. Teacher-mentors received the interview questions in advance as part of the collaborative training partnership. The PSTs made written records of teachers' responses. They also recorded field notes and reflective evaluations during and after observing or teaching inquiry or SSI-related learning activities. All data were brought back to the university and shared with peers and tutors in collaborative learning conversations as part of SSIBL training workshops. Then one of the authors made summary field notes of sample dialogue.

Teacher interview data, PSTs' observational and reflective field notes were then analysed through iterative thematic content analysis to establish teachers' beliefs about, and practices in, inquiry and SSI-related learning for the curriculum.

After the process of creating SSIBL activities, PSTs' reflective reviews were analysed and an evaluation was conducted with a sample of PSTs using questionnaires and group interview.

5. Results

81% of the teachers interviewed by the PSTs felt that true inquiry should be student-led with students asking their own questions, e.g.: 'When science answers students' own questions, it becomes part of them'.. Accounts of practice, however, diverged from aspirations. 89% of the teachers interviewed reported inquiry as being highly or moderately teacher-controlled and identified its purposes as learning and practising procedural skills prior to compulsory school assessments at higher secondary level. Teachers usually plan 'typical' guided practical activities. Common approaches to guided inquiry involved introducing an idea, encouraging some student-initiated questions followed by the teacher deciding on selected questions to be taken forward to avoid 'unhelpful' outcomes. Occasionally, students' own questions emerged spontaneously but rarely became the foci of inquiry. There was little evidence of authentic, socially-responsible action evolving from inquiry in science lessons [7]. Instances of the use of SSIs were almost always initiated through teacher question and guided by established resources; for example, should IVF be universally allowed? The learning goal was usually independent research and debate. Teachers often asked students to 'research on the internet' but did not acknowledge this as an aspect of inquiry. They view inquiry as 'practical investigation' as laid out in the narrow definition in the 2014 science national curriculum (https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study). Detailed interviews of practise were carried out with three students: Monica, Carol and Jules. Monica's SSIBL project on smoking received enthusiastic support from her school mentor and is now incorporated in the curriculum for future years. Using photographs to stimulate discussion on the topic of *Healthy Living* in her class of 14-year old students, the students then collaborated to create online anonymised survey questions on smoking to send to friends and family. They then created a

campaign to deter other teenagers from smoking. According to Monica: 'Engagement in the topic was key, the right age for smoking. They could see how the science we had studied linked into what we were looking at. The different parts of the respiratory system that become affected by smoking, so knowing that, why would people smoke, and this led them to come up with their own specific questions to try and understand why.' Monica also noted the importance of students evaluating responses for face validity and reliability. Jules's students' ideas began as they were studying products from crude oil; a stimulus video showed how slowly plastic degrades, then they focused on the use of plastic bottles in school; his mentor thought it was a very good idea and helped to generate the activity. Jules encouraged the students to collectively devise an inquiry question: 'why does the school canteen continue to sell drinks in plastic bottles, knowing the environmental problems of their disposal?'

After an exploratory survey the students felt it might be too contentious; the inquiry would put them up against canteen staff and senior management so challenging authority. Paradoxically the fact the students felt they might have some power to change something, Jules felt, might have scared them. But it was beneficial for them to feel they were doing something that actually mattered. They felt the controversy could have been 'cooled' [8] had they focused on plastic bottles from their homes.

Carol's focus was on health and cycling to school. Despite student interest there was little support from school staff, partly because of the risks of outdoor learning.

6. Conclusions

The emphasis on performativity in U.K. schools [9] is not propitious for developing SSIBL activities. However, combined with an underpinning willingness from established teachers and innovation from PSTs there are clear possibilities for development. Obstacles were a difficulty in moving away from substantive science, lack of teacher support, and a fear of politicising an issue.

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