Science in and for Society: SSIBL at University of Southampton

Course outline and lesson plans for SSIBL teacher professional development (TPD) sessions for pre-service science teachers in lower-secondary education

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Overview of course outline

Short summary	The TPD course that we have designed for pre-service teachers (PSTs) consists of a number of up to five workshops and three independent study tasks that aim to progressively involve PSTs in teaching science based on socio-scientific inquiry-based learning (SSIBL). During these face-to-face sessions we adopted an implicit approach to the SSIBL framework, by presenting and discussing its various components gradually. This allowed teachers to gradually make links to own experiences from teaching science or observing science being taught and then considering these experiences in relation to the different types of inquiry (from open to structured) and the different ways in which links to societal and political/economic/ethical issues could be achieved. We engaged our teachers in activities where they had to take on the role of the learner in order to model for them how they could address controversies in their classroom settings (e.g. we used a mapping controversies task on a local SSI – the transmission of bovine tuberculosis to cattle from badgers), how they could discuss uncertainty and risk in scientific data (through the climate change scenario) and how they could run debates on challenging, controversial issues (e.g. testing drugs on animals). PSTs then took on the role of designer in order to develop lesson plans to teach various topics using the SSIBL approach and the role of the teacher by implementing their resigns, and critically reflecting on their own teaching practices. The duration of the TPD sessions is up to 24 face-to-face hours. The independent tasks require students to engage with the research literature on issues surrounding SSIBL, including reflections on how such an approach could be implemented in the classroom in order to produce a masters level coursework. The second task required PSTs to conduct a small-scale classroom-based intervention (action research) related to implementing SSIBL, and write it up in order to produce a second masters level coursework. Finally, all PSTs are assigned an independent school-based task of designing, implementing and evaluating the teaching of a SSIBL-based lesson or activity.

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Intended learning objectives of the TPD	O1. Consider their own beliefs on the nature of science, how science is represented in school contexts, and how these beliefs might influence their teaching practices. O2. Consider the place of SSIBL in the context of science education for the 21st century. O3. Analyse teaching scenarios according to elements of the SSIBL framework. O4. Reflect on the various elements of the SSIBL framework and on the skills required for these elements to be implemented in science classrooms. O5. Engage with the research literature on aspects relating to the SSIBL framework (socio-scientific issues, citizenship education, inquiry-based learning, responsible research and innovation). O6. Design and implement SSIBL-based activities in their science classrooms. O7. Evaluate the implementation of their SSIBL activities in terms of (a) their teaching effectiveness and (b) pupil learning. O8. Critically reflect on their own skills in relation to teaching based on SSIBL and identify areas for further professional development.

Workshop no.	Duration	Main Activity/ objectives	Approach
1	*2h*	• consider how the nature of science is represented in science classrooms • critically reflect on own views of what science is, and how it should be taught • consider the place of SSIBL in the context of science education for the 21st century	*Teachers as learners*
2	6h	• consider how investigation questions can be re-formulated into authentic questions • consider how authentic contexts can be used when teaching science • analyse teaching scenarios according to components of the SSIBL approach (• model how SSIBL can be enacted in classrooms, through 3 different scenarios (in biology, chemistry, and physics) • discuss and reflect on the skills required for SSIBL elements to be implemented in science classrooms	*Teachers as learners* *Teachers as developers* *Teachers as reflective practitioners*

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3	2.5h	• consider the place of argumentation in science and science education • consider and practice various pedagogical strategies for incorporating deliberation, decision-making and argumentation in science teaching critically reflect on their role as teachers during collaborative activities • analyse types of questioning taking place during group work • consider how to scaffold students' productive classroom discourse and interactions during SSIBL activities	*Teachers as learners* *Teachers as reflective practitioners*
4	6h	• consider the implementation of SSIBL in the context of health education • share good practice and resources that are based/related to SSIBL • discuss how PSTs could develop their practice further as they begin their first year of teaching	*Teachers as learners* *Teachers as developers* *Teachers as reflective practitioners*
5	8h	• consider how authentic contexts can be used when teaching science • share good practice and resources that are based/related to SSIBL • design and implement SSIBL-based activities for their science classrooms • evaluate the implementation of their SSIBL activities in terms of (a) their teaching effectiveness and (b) pupil learning	*Teachers as teachers* *Teachers as reflective practitioners*

Independent task 1	• engage with the research literature on aspects relating to the SSIBL framework • reflect on the various elements of the SSIBL framework and on the skills required for these elements to be implemented in science classrooms	*Teachers as researchers*
Independent task 2	• engage with the research literature on aspects relating to the SSIBL framework • design and implement SSIBL-based activities in their science classrooms • evaluate the implementation of SSIBL activities in terms of (a) their teaching effectiveness and (b) pupil learning • Critically reflect on their own skills in relation to teaching based on SSIBL and identify areas for further professional development	*Teachers as researchers* *Teachers as teachers* *Teachers as developers* *Teachers as reflective practitioners*

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Independent task 3	• share good practice and resources that are based/related to SSIBL • develop and implement SSIBL-based activities in their science classrooms • evaluate the implementation of their SSIBL activities in terms of (a) their teaching effectiveness and (b) pupil learning	Teachers as developers Teachers as teachers Teachers as reflective practitioners

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WORKSHOP 1[i]

Duration: 2h

Learning goals: By the end of this session, pre-service teachers would have had the opportunity to

- consider how the nature of science is represented in science classrooms
- consider how the nature of science is represented in the aims and objectives of the National Curriculum under the tenet of *Working Scientifically* at Key Stage 3 and Key Stage 4
- critically reflect on own views of what science is, and how it should be taught
- consider the place of SSIBL in the context of science education for the 21st century

Teaching and learning activities employed during session 1

1) Present aims and outline of session; discuss aims of National Curriculum and what the Working Scientifically tenet looks like at Key Stage 3 and Key Stage 4 (20 minutes)
2) Ask students to reflect on, and write down their own definitions of what science is individually (keep this definition, so they can reflect and add on/change at the end of the session) (10 minutes)
3) Share and discuss some of students' definitions; then, go through some of the Chen (2006) items of an instruction for assessing views of the nature of science (20 minutes)
4) Focus on Observation and Inference – Animal footprints and Tricky Tracks activities (20 minutes)
5) Discuss aspects of the nature of science based on literature (e.g. Osborne et al., 2003) (10 minutes)
6) Consider and discuss why it is important to understand your own view of science, as a science teacher (10 minutes)
7) Consider and discuss the role of society, science for all, and socio-scientific inquiry based learning in science education (10 minutes)
8) Watch the Pursuit of Ignorance TEDTalk by Stuart Firestein (http://on.ted.com/Firestein) (10 minutes)
9) Reflect on initial definitions of what science is (10 minutes)

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WORKSHOP 2[i]

Duration: 6 hours (full day)

Learning goals: By the end of this session, pre-service teachers would have had the opportunity to:

- Consider how typical investigation questions can be re-formulated into authentic questions that address socially responsible issues
- consider how authentic contexts can be used when teaching science
- analyse teaching scenarios according to components of the SSIBL approach
- participate as learners in three difference scenarios (in biology, chemistry, and physics), which model how SSIBL can be enacted in classrooms, through three different scenarios
- discuss and reflect on the skills required for SSIBL elements to be implemented in science classrooms
- plan SSIBL lessons based on the scenarios (in biology, chemistry, and physics) in which they participated

Teaching and learning activities employed during Workshop 2

Before the session: If pre-service teachers are in a school placement during the time of this workshop, ask them to have a discussion with their mentors about the place of inquiry in science, and to collect some notes from this discussion. Also, ask them to make some notes on observations from different types of inquiry they have seen taking place in their placement school, or from lessons they have taught.

During the session:

1) Introduction to the session's aims (5 minutes)
2) PSTs work in groups of three to share and reflect on their views of inquiry based on notes taken from meeting with their school-based mentor (questions provided to PSTs to scaffold this discussion include: What is inquiry? Is it important? How does it take place? How is it (if at all) different to 'normal' science teaching? What do the pupils and teachers do in inquiry-based learning?). Share group discussion with whole group. Point out that inquiry and practical investigations/experiments are not the same, although often used synonymously. Discuss different types of inquiry (30 minutes).
3) Introduce socially responsible inquiry and meaning of 'authenticity' in science education; provide PSTs with typical investigation questions and ask them to reformulate them to make them more authentic; then, ask students to re-organise reformulated questions into those that have a social, global or personal relevance dimension (30 minutes).
4) Discuss the importance of Taking Action for socially responsible inquiries and share/discuss examples of what this could look like in science classrooms (10 minutes).
5) Introduce 'socio-scientific issues', their relevance and importance for science education (10 minutes)

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6) Mapping controversies using the scenario of bovine tuberculosis in cattle and the subsequent culling of badgers in England as a way to control its spread (25 minutes) (see TPD presentations, Workshop 2 for instructions given to PSTs).
7) PSTs share their maps in whole group and discuss how this strategy can be used in their teaching practice (15 minutes)
8) SSIBL in action – PSTs get into three groups; each group will engage with one scenario as learners (45 minutes). They then plan a lesson based on this scenario in smaller groups (45 minutes)[ii].

a. Scenario 1: Testing drugs on animals

PSTs investigate the question: *Would you sign a petition for a ban on using animals to test new drugs?*

They are asked in groups of three to identifying as many factors / ideas /stakeholders as possible in relation to the animal testing controversy, and then to identify the various arguments for and against using animals for drug trials. They then have to engage in a role-play activity where they take on different roles, research evidence and construct arguments based on their role. PSTs have a debate, and then reflect on whether this has changed their original views about the key questions, three points they consider to be the most effective in backing up their personal views, and what action they would take to promote their position on this issue.

PSTs are given a lesson plan template (see handout materials) and asked to plan a lesson or series of lesson based on Scenario 1.

b. Scenario 2: Electricity and renewable sources

PSTs investigate the question*: Is the UK government's decision to invest in new nuclear power plants short-sighted?*

Students are given a short editorial article entitled 'Power Struggle' (Nature, 2015) to read. They are then ask to consider what questions they have as a result of reading the 'Power Struggle article', what else they would like to know to be able to make a decision about the key question, and what they consider the arguments for and against using nuclear power plants are. They are then given two main positions (see TPD presentations, Workshop 2), laptops and some online resources and are asked to identify evidence for and against both positions before making a decision on the key question. Finally, PSTs then reflect on whether this task has changed their original views about the key question, three points they consider to be the most effective in backing up their personal views, and what action they would take to promote their position on this issue.

PSTs are given a lesson plan template (see handout materials) and asked to plan a lesson or series of lesson based on Scenario 2.

c. Scenario 3: Climate change – levels of controversy and nature of evidence used

PSTs investigate the question*: Is it our fault that our planet is getting warmer?*

PSTs work in groups of three to sort out a set of evidence statements given to them (based on information retrieved from Wolff (2014) and Busch & Osborne (2014)) in four categories: for/against climate change being human-made and for/against climate change naturally occurring. PSTs are then asked to consider the nature of the evidence they have (quantity

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and quality; difference between factual information and information drawn from statistical modelling and simulations) when making a decision about who is causing global warming. They are then asked in their groups to consider solutions, make a group decision, and also reflect and review on their personal view about the key questions.
PSTs are given a lesson plan template (see handout materials) and asked to plan a lesson or series of lesson based on Scenario 3.

9) Each of the three groups, present and discuss in whole group their lesson plans and experiences of 'SSIBL-in-action' at the end of the session. As part of the reflection process they are asked to make a 'SSIBL pledge' for them personally, and for their teaching (45 minutes). The pledges are collected in envelopes and returned at the end of the year to each PSTs for further reflection and discussion.

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WORKSHOP 3[i]

Duration: 2.5 hours

Learning goals: By the end of this session, pre-service teachers would have had the opportunity to:

- consider the place of argumentation in science, and in science education
- consider and practise various pedagogical strategies for incorporating deliberation, decision-making and argumentation in science teaching and SSIBL
- critically reflect on their role as teachers during collaborative activities
- analyse types of questioning taking place during group work
- consider how to scaffold students' productive classroom discourse and interactions during SSIBL activities

Teaching and learning activities employed during Workshop 3

1) Introduction to the session's aims (5 minutes)
2) Introduction to argumentation in science education: this consists of a short presentation on what argumentation is, how it is linked to educational approaches such as dialogic teaching, and what argumentation could look like from a structural perspective based on the Claim-Evidence-Reasoning framework developed by McNeill & Krajcik (2011) – see TPD presentations for more details (20 minutes)
3) PSTs are shown details of an argumentation lesson and analyse collaboratively the teacher's actions in this process with an emphasis on the teacher's role in promoting productive classroom talk, and teacher questioning (30 minutes)
4) PSTs are organised into groups of three and engage in an argumentation activity using a concept cartoon and an argument template (see IDEAS pack, Osborne, Erduran & Simon, 2004). They use the 'listening triads' strategy (where each member of the group takes the role of the speaker, questioner, recorder) to analyse their views and construct an argument collaboratively (45 minutes).
5) Groups reflect on their experiences as learners at the end of the listening triads activity. Other ideas and issues raised when organising groupwork are shared and discussed with PSTs (20)
6) PSTs are given different written explanations based on various concepts they have to teach and are asked to work in pairs (one takes the role of the student; the other the teacher). They are asked to 'teach' the given explanation attempting to ask higher-order questions, and prompt their 'student' to engage in argumentation/reasoning in the process (20 minutes)
7) Other resources and ideas of how to organise groupwork and argumentation are shared and discussed as a plenary with PSTs at the end of the session (10 minutes).

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WORKSHOP 4[i]

Duration: 6 hours

Learning goals: By the end of this session, pre-service teachers would have had the opportunity to:

- consider the implementation of SSIBL in the context of health education
- share good practice and resources that are based/related to SSIBL
- discuss how PSTs could develop their practice further as they begin their first year of teaching

Teaching and learning activities employed during Workshop 4

1) Introduction to the session's aims (10 minutes)
2) Placing SSIBL within a Health context: PSTs are shown the question 'Obesity crisis: could *you* make a difference?' in order to model how a SSIBL question could be used to introduce a lesson on healthy living and wellbeing. They are then asked to work individually to think about their own health and make a pledge about their own health (30 minutes)
3) PSTs are then introduced to the topic of the session; obesity is framed as one of the grand challenges of the 21st century, and this issue is then contextualised within the UK using different news stories (20 minutes)
4) PSTs are given background information on the concept of 'epigenetics' and how this influences individuals' genetic make-up. Then, they are introduced to the Lifelab project (https://www.efolio.soton.ac.uk/blog/lifelab/) and the teaching resources that have been produced and used with secondary school pupils (Bagust et al., 2015) (30 minutes)
5) PSTs then take part in a circus of activities that aim to help them measure their health (these activities are the activities that pupils conduct when visiting the Lifelab facilities with their teachers; e.g. measuring grip strength, lung capacity, blood pressure, flexibility and jump height etc.) (90 minutes)
6) PSTs work in groups of 3-4 to design SSIBL lesson units and activities to address the Lifelab message of 'Me, my health and my children's health'. Emphasis is placed on assessment (how knowledge, values and skills will be assessed) (90 minutes)
7) PSTs present their work in whole class (60 minutes)
8) The session ends with a whole group reflection on the place of SSIBL in science teaching and learning, and on their experiences of trying to use SSIBL in the classroom during their training years. Additional information on support and resources is provided for those that are interested to continue using SSIBL (30 minutes).

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WORKSHOP 5[i]

Duration: 8 (2 & 6) hours

Learning goals: By the end of this session, pre-service teachers would have had the opportunity to:

- consider how authentic contexts can be used when teaching science
- consider the place of SSIBL in the context of science education for the 21st century
- engage with the research literature on aspects relating to the SSIBL framework
- share good practice and resources that are based/related to SSIBL
- design and implement SSIBL-based activities in their science classrooms evaluate the implementation of their SSIBL activities in terms of (a) their teaching effectiveness and (b) pupil learning

Teaching and learning activities employed during Workshop 5

Workshop 5 consists of two parts. First a 2 hour planning session for PSTs on the outdoors activities they will conduct with pupils, and second, the outdoors learning day (6 hours). The activities to be conducted during the outdoors day have been prepared in advanced by the school teachers that have collaborated with us in this workshop (Thornden School, Eastleigh) and PSTs are asked to consider their input during these activities, as well as how they can incorporate elements of SSIBL into them.

a. Planning session

1) Introduction to the session's aims and background information on the outdoors setting that PSTs and pupils will be visiting (10 minutes)
2) Short introduction to SSIBL and outdoors learning; focus is on authentic questioning within the context of biodiversity (15 minutes)
1) PSTs plan questions and activities they could run with the pupils during the outdoors day to a National Trust site (Foxbury; https://www.nationaltrust.org.uk/new-forest-northern-commons/lists/new-forest-northern-commons---foxbury). The activities include a) an icebreaker activity since these are students that PSTs have not worked with before, b) a tree study activity where pupils explore the site and have to identify up to 10 trees, and estimate the tree's height, circumference and age, c) invertebrate study activity where pupils are asked to choose an area to explore and find different species of invertebrates, which they then have to name and observe for adaptations to their environment d) a vegetation study activity where pupils have to identify different plants (e.g. gorse, heather, flowers, grass etc.) within the areas they are exploring outdoors, e) a biodiversity walk activity where pupils walked around the site with the PSTs and had to tally up the number of species they identified in each area on the walk, and make notes of any interesting organisms they came across, taking pictures if they couldn't identify the organisms (this then could lead into discussions about the value of conservation vs. forestry plantation) (95 minutes)

b. Visit to National Trust site: PSTs spend the day outdoors with the pupils, guiding them through the activities described above.

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[i] Please see TPD presentations document for more details about information shared during the Workshop.

[ii] Please see Materials and Handouts documents for more details about materials used during the three scenarios, the SSIBL summary handout, the SSIBL lesson plan template, and the SSIBL pledge handout.

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