DEVELOPMENT AND ASSESSMENT OF SCIENTIFIC LITERACY THROUGH STUDENT-LED SOCIO-SCIENTIFIC RESEARCH IN PRE-SERVICE TEACHER EDUCATION

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Outline

I. Scientific literacy
II. Socio-scientific research for the development and assessment of scientific literacy
III. Student-led socio-scientific research in a pre-service teaching module.
IV. Pre-service teachers’ experiences of socio-scientific research
V. Scientific literacy competencies used in socio-scientific research
VI. Conclusion and implications
Scientific Literacy is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen.

A scientifically literate person, therefore, is willing to engage in reasoned discourse about science and technology...
PISA 2015 - Scientific Literacy

... which requires the competencies to:

1. Explain phenomena scientifically
2. Evaluate and design scientific enquiry
3. Interpret data and evidence scientifically

OECD 2013
1. Explain phenomena scientifically

A. Recall and apply appropriate scientific knowledge;
B. Identify, use and generate explanatory models and representations;
C. Make and justify appropriate predictions;
D. Offer explanatory hypotheses;
E. Explain the potential implications of scientific knowledge for society.

OECD 2013
2. Evaluate and design scientific enquiry

A. Identify the question explored in a given scientific study;
B. Distinguish questions that are possible to investigate scientifically;
C. Propose a way of exploring a given question scientifically;
D. Evaluate ways of exploring a given question scientifically;
E. Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalisability of explanations.

OECD 2013
3. Interpret data and evidence scientifically

Transform data from one representation to another;

Analyze and interpret data and draw appropriate conclusions;

C. Identify the assumptions, evidence and reasoning in science-related texts;

D. Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;

E. Evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals).

OECD 2013
PISA Scientific Knowledge

In addition to the three competencies, the scientifically literate person has the following types of knowledge:

- Content knowledge
- Procedural knowledge
- Epistemic knowledge

Previously known as knowledge of science

Previously known as knowledge about science

Incorporates elements of Nature of Science
Socio-scientific research

- Student-led socio-scientific research tasks can be used to develop and assess many of the competencies associated with scientific literacy.
- The benefits of such tasks are...
  - They provide real life contexts.
  - They can be personalised by the student to suit their own interests.
  - Topics tend to be more contemporary and can focus on cutting edge science, increasing student interest.
    Zeidler & Nichols 2009

Socio-Scientific Research in Irish Junior Cycle

- The student will
  - Research a socio-scientific issue
  - Analyse information/secondary data
  - Evaluate the claims and opinions studied
  - Draw evidence based conclusions about the issues involved

“Students will collaborate as they prepare scientific communications for a variety of purposes and audiences.”

“They will learn about, and make informed decisions about, their own health and wellbeing, and about science-related issues of social and global importance”

NCCA 2015
Student-led socio-scientific research in a pre-service teaching module.

- The study was conducted over two years with two cohorts of pre-service teachers (PSTs), a total of 50 students.
- Students were in their second year of a four-year undergraduate degree in mathematics, chemistry, and physics teaching.
- The task was based on the Junior Cycle Science in Society Investigation.
Student-led socio-scientific research in a pre-service teaching module.

Phase 1: Research
Pre-service teachers carried out research over 3 hours. PSTs were given one week to upload an electronic document containing their research information and sources.

Phase 2: Communicating Findings
PSTs were given one hour to use complete a report using only the information gathered previously.

Phase 3: Evaluation of the task
Pre-service teachers’ experiences of socio-scientific research

After completion of the SSI the PSTs completed a questionnaire reflecting on their experience...

Think about your experience of the National 5 Assignment as a whole from the introductory lesson(s) to the research stage to the communication (report-writing) stage. The following questions ask you to talk about your own experiences and how you felt the National 5 Assignment went for you. This includes the skills and knowledge you feel you, personally developed through carrying out the Assignment.

START OF QUESTIONS
• What do you think are the learning intentions and success criteria of the National 5 Assignment in Science?
• From your experience of carrying out the National 5 Assignment, list the top 3 things you learnt? This may be knowledge or skills or something else. Give an example for each.
• What about the National 5 Assignment went particularly well for you? Give examples.
• What about the National 5 Assignment was particularly challenging for you? Give examples.
• If you had the chance to complete the Assignment again, what changes, if any, would you make to how you carried out your assignment?
Scientific literacy competencies used in socio-scientific research

...and completed a checklist of PISA competencies used

<table>
<thead>
<tr>
<th>Competency or Knowledge type</th>
<th>Skill used (✓/X)</th>
<th>If skill was used, give examples of when or how you used this skill during the Assignment</th>
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</thead>
<tbody>
<tr>
<td>a Recall and apply appropriate scientific knowledge;</td>
<td></td>
<td></td>
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<tr>
<td>b Identify, use and generate explanatory models and representations</td>
<td></td>
<td></td>
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<tr>
<td>c Make and justify appropriate predictions</td>
<td></td>
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<td>d Offer explanatory hypotheses</td>
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<tr>
<td>e Explain the potential implications of scientific knowledge for society</td>
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</table>
Pre-service teachers’ experiences of socio-scientific research

- Thematic analysis was carried out on the students reflections.

- The method used was based on Braun & Clarke (2006)
PSTs experience of the SSI

Skills

Knowledge

Impact on society & the environment

Thematic analysis identified three main themes
Skills

Researching and managing information
Differentiating between sources
Evaluating sources
Finding information
Selecting information
Organising information
Comparing information

Presenting
Report writing
Communicating Structure

Questioning
Choosing questions
Asking questions
Answering questions

Personal
Working independently
Planning
Forming an opinion
Knowledge

How & What

Stated “fact” / knowledge related to topic

Impact on society & the environment

Global/ National/ Personal & the environment

Application

Benefits

Disadvantages
Pre-service teachers’ experiences of socio-scientific research

- PSTs talked about their experience in terms of three themes:
  - Skills
  - Knowledge
  - Impact on society & the environment
- The largest theme was skills, consisting of four sub-themes:
  - Researching and managing information
  - Questioning
  - Presenting & report writing
  - Personal
Scientific literacy competencies used in socio-scientific research

- Quantitative analysis was used to identify which competencies students felt they had used in completing the SSI.
Recall and apply appropriate scientific knowledge; Identify, use and generate explanatory models and representations; Make and justify appropriate predictions; Offer explanatory hypotheses; Explain the potential implications of scientific knowledge for society.
Identify the question explored in a given scientific study; Distinguish questions that are possible to investigate scientifically; Propose a way of exploring a given question scientifically; Evaluate ways of exploring a given question scientifically; Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalisability of explanations.

"I used different sources of different reliability and quality" "I thought about how to explore the question" "Using multiple sources for research" "Check if data is available in more than one source"
Interpret Data & Evidence Scientifically

- Used the information in the report to make a conclusion
- I drew my own opinion
- That is the reason I interred
- I read many articles, they were quite biased
- Identified evidence from physics books
- yes, when reading articles identifying and segregating beliefs from facts
- Separated reliable sources i.e. Journals, from potentially unreliable sources like forums
- range of sources evaluated

PISA Competency: Interpret Data & Evidence Scientifically

- Transform data from one representation to another
- Analyse and interpret data and draw appropriate conclusions
- Identify the assumptions, evidence and reasoning in science-related texts
- Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations
- Evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals)
## Scientific literacy competencies used in socio-scientific research

<table>
<thead>
<tr>
<th>Competency</th>
<th>Average 2015</th>
<th>Average 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain phenomena scientifically</td>
<td>56%</td>
<td>59%</td>
</tr>
<tr>
<td>Evaluate and design scientific enquiry</td>
<td>40%</td>
<td>55%</td>
</tr>
<tr>
<td>Interpret data and evidence scientifically</td>
<td>43%</td>
<td>59%</td>
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- Each competency was used by at least 25% of students
- Evaluate and design scientific enquiry was the least used competency
- The cohort in 2016 felt they used more competencies of scientific literacy than the cohort in 2015.
Conclusions and Implications

- Pre-service teachers (PSTs) carried out a student-led socio-scientific research task based on the Irish Junior Cycle Science in Society Investigation.
- PSTs experience focused on the skills used during the SSI.
- PSTs self-identified scientific literacy competencies used in socio-scientific research.

- What are the implications of this for second level students?
Development or Assessment of scientific literacy?

“The purpose of assessment and reporting at this stage of education is to support learning.”

NCCCA 2015 P21

“Students should have developed sufficient knowledge, skills and understanding over the course of first, second and third year to undertake an SSI in the middle of third year.”

NCCCA 2016 p24
References


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Thank you for listening

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