Investigating and Addressing Chemistry Misconceptions in the Subject Matter Knowledge and Pedagogical Content Knowledge of Pre-service Science Teachers

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Terminology: Misconceptions

- Many different terms: pre-conceptions, learners’ ideas, alternative conceptions, alternative frameworks.

- Definition used in this study:
  “any conceptual idea that differs from the commonly accepted scientific consensus” (Cho et al. cited in Garnett et al. 1990).
**Focus of Project**

**Phase 1**
- to investigate the Subject Matter Knowledge (SMK) of pre-service science teachers (PSSTs) in Ireland in relation to a number of misconceptions about basic chemistry concepts.

**Phase 2**
- to improve the SMK of PSSTs about basic chemistry concepts and develop their Pedagogical Content Knowledge (PCK) about addressing the chemistry misconceptions among their future pupils.

**Developed Chemistry Misconceptions Identification Instrument (CMII)**

11. Which of the following best represents the ionic compound sodium chloride (NaCl)? (Click the correct answer)

   A  B  C  D  E

**Piloted with 212 PSSTs**

**Administered to 467 PSSTs across Ireland**

16. Consider the following reaction:

\[ \text{H}_2 (g) + \text{I}_2 (g) \rightleftharpoons 2 \text{HI} (g) \]

If \( \text{H}_2 \) and \( \text{I}_2 \) are mixed together and allowed to come to equilibrium, what would the graph of the concentration of \( \text{H}_2 \) look like over time? (Note: Temperature remains constant)

Circle the correct answer: A B C D E
Sample Group

Consecutive

6 institutions in ROI and 1 in NI run consecutive science programmes

4 Year Undergraduate Degree Programme in Science

1 Year Professional Diploma in Education

144 PSSTs in all 7 consecutive institutions in Ireland

Entry to Teaching Profession

Concurrent

4 institutions in ROI and 2 in NI run concurrent science programmes

4 Year Undergraduate Degree in Science, Science Pedagogy & Education

323 PSSTs in 4 concurrent institutions in Ireland
• 49.9% of PSSTs achieved less than 40% in the diagnostic instrument.
• A further 13.9% achieved exactly 40% in the instrument.
• The mean score for the instrument was 37.4%.
Sample of Misconceptions

All the macroscopic properties of a substance can be attributed to a single atom (32%).

A substance composed of only one compound is a homogeneous mixture (50%).

Covalent bonds break on boiling (20%).

The mass of a particle affects the number of particles in a mole (43%).

Breaking covalent bonds releases energy (32%).

$2\text{SO}_3$ means the same thing as $\text{S}_2\text{O}_6$ (38%).
Relationships with No Significance

Mode of Entry to Teaching Profession

• No Significance

Year of Study in Concurrent Programmes

• No Significance
Summary of Phase 1 Results

- Mode of entry to the teaching profession or the number of years spent on a concurrent course has no effect on PSSTs’ chemistry misconceptions.

- There is no correlation between studying more chemistry or chemistry pedagogy and understanding more chemistry!
Phase 2: Blended Learning Intervention
What is Blended Learning?

- Blended learning has been described as “learning activities that involve a systematic combination of co-present (face-to-face) interactions and technologically-mediated interactions between students, teachers and learning resources” (Bliuc et al. 2007).

- These experiences (online and face-to-face) are integrated such that the strengths of each are blended into a unique learning experience that is congruent with the context and the intended educational outcome (Garrison & Vaughan 2011).

- **Context**: 2nd Year pre-service science teachers soon to go on teaching placement.

- **Intended educational outcome**: pre-service science teachers will also increase their awareness of and address misconceptions in their own SMK by focusing on addressing the misconceptions of their pupils (i.e. focusing on their PCK).
### Blended Learning Intervention: Sample Group

<table>
<thead>
<tr>
<th></th>
<th>Intervention Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. PSSTs</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>No. qualified to teach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower second-level science</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>No. qualified to teach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper second-level chemistry</td>
<td>26 (81%)</td>
<td>14 (67%)</td>
</tr>
<tr>
<td>No. undecided about</td>
<td></td>
<td></td>
</tr>
<tr>
<td>specialising in chemistry</td>
<td>1 (3%)</td>
<td>2 (10%)</td>
</tr>
<tr>
<td>or physics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is no statistically significant difference ($p > 0.05$) between the intervention and control groups in their motivation to learn or their learning strategies as measured by the Motivated Strategies for Learning Questionnaire.
The Blended Learning Intervention

- Face-to-Face
- Collaboration & Community
- Web-based Learning

- Concept Mapping
- Diagnostic Questions
- Cooperative Learning
- Concept Cartoons
- SuBATOMIC Website
• A website designed and built as part of this project.
• The intention is that this is a place where the PSSTs can:
  – revise their own understanding of lower second-level (Junior Certificate) chemistry topics,
  – learn about common pupil misconceptions which they may come across in the classroom,
  – get diagnostic questions, resources, ideas for teaching activities and information about the Junior Certificate science syllabus,
  – learn about research ideas and strategies relevant to developing conceptual understanding and targeting misconceptions among their pupils, and,
  – get advice from experienced teachers/researchers about teaching chemistry (in the form of short articles)
Resources

Advice from Experienced Teachers

Junior Certificate Science Syllabus

Lesson Planning

Revise Own Understanding

Research Based Teaching Activities

Advice from Science & Chemistry Education Research Literature

Prepare for Common Pupil Misconceptions

ONE STOP SHOP
• A temporary user name and password have been set up for conference members to use the site. This will be available today and tomorrow.

  Username: ICTT_2013

  Password: reaction
Conclusions (based on Phase 1 only)

- Initial science teacher training programmes in Ireland are not successful in developing pre-service science teachers conceptual understanding of basic chemistry concepts.

- The type of initial teacher training programme (concurrent or consecutive) has no impact on understanding of basic chemistry concepts as measured by the CMII.
Thank you for your Attention

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