The Effectiveness of a Professional Development Program on the use of STEM-based 5E Inquiry Learning Model for Science Teachers in China

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ABSTRACT

In 2001, following China’s launching of its curriculum reform of basic education (Ministry of Education, 2001), a series of curriculum standards and policy documents were conceptualized which included the integrated science curriculum standards for primary and middle schools, individual subject (physics, chemistry, biology, and geography) curriculum standards for middle and high schools (Wang et al., 2016). In HVHVFKHFHUXULFXOPXUHRUVPSHFHVVLJ[DUHVDFXUH]scale curriculum change: (1) Mode of learning (from passive knowledge adsorption to that of active knowledge construction); (2) curriculum structure (from a discipline-based to that of a more flexible, school-based curriculum and student-centered); (3) teaching and learning (from rote and memorized learning to that of inquiry and problem-based learning, cooperative learning, and placement focus to that of one that improves learning and creative problem-solving skills); (4) pedagogical (from lecture and rote learning connected to the broader scientific, technological, and social contexts to that of content (from textbook-based knowledge to that of knowledge acquired based on students' experience and interests and is scale curriculum change: (1) Mode of learning (from passive knowledge adsorption to that of active knowledge construction); (2) curriculum structure (from a discipline-based to that of a more flexible, school-based curriculum and student-centered); (3) teaching and learning (from rote and memorized learning to that of inquiry and problem-based learning, cooperative learning, and placement focus to that of one that improves learning and creative problem-solving skills); (4) pedagogical (from lecture and rote learning connected to the broader scientific, technological, and social contexts to that of content (from textbook-based knowledge to that of knowledge acquired based on students' experience and interests and is scale curriculum change: (1) Mode of learning (from passive knowledge adsorption to that of active knowledge construction); (2) curriculum structure (from a discipline-based to that of a more flexible, school-based curriculum and student-centered); (3) teaching and learning (from rote and memorized learning to that of inquiry and problem-based learning, cooperative learning, and placement focus to that of one that improves learning and creative problem-solving skills); (4) pedagogical (from lecture and rote learning connected to the broader scientific, technological, and social contexts to that of content (from textbook-based knowledge to that of knowledge acquired based on students' experience and interests and is scale curriculum change: (1) Mode of learning (from passive knowledge adsorption to that of active knowledge construction); (2) curriculum structure (from a discipline-based to that of a more flexible, school-based curriculum and student-centered); (3) teaching and learning (from rote and memorized learning to that of inquiry and problem-based learning, cooperative learning, and placement focus to that of one that improves learning and creative problem-solving skills); (4) pedagogical (from lecture and rote learning connected to the broader scientific, technological, and social contexts to that of content (from textbook-based knowledge to that of knowledge acquired based on students' experience and interests and is scale curriculum change: (1) Mode of learning (from passive knowledge adsorption to that of active knowledge construction); (2) curriculum structure (from a discipline-based to that of a more flexible, school-based curriculum and student-centered); (3) teaching and learning (from rote and memorized learning to that of inquiry and problem-based learning, cooperative learning, and placement focus to that of one that improves learning and creative problem-solving skills); (4) pedagogical (from lecture and rote learning connected to the broader scientific, technological, and social contexts to that of content (from textbook-based knowledge to that of knowledge acquired based on students' experience and interests and is
Ong, et al.: The effectiveness of a STEM-based 5E Inquiry Learning PD program

What is the effect of the STEM-based 5E Inquiry Learning Model? For example, the engineering component is integrated into the elaboration phase, where the pedagogical function for each of the phases is clearly defined. In this study, the research questions are

**What are the views by means of self-perceived written reflections on what the participants have gained which were not known before the professional development?**

**What is the learning achievement of the participants in the topic of the electric circuit?**

**What is the effect of the STEM-based 5E Inquiry Learning Model professional development program on the learning achievement of the participants in the topic of the electric circuit?**

**What base of activities within which current concepts (i.e., science and mathematics) and additional activities are exemplified and given to the participants?**

**How do the participants think towards the learning outcomes of current activities?**

**What do the participants think about the conceptual and process skills in relation to the investigation?**

**What activities do the participants conduct and design a preliminary investigation?**

**What do the participants develop a deeper and broader understanding, critical thinking, and problem-solving skills?**

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**METHODOLOGY**

**JPHQWXRQHURQSGROHDOQWLRQ**

- **JPHQWXRQHURQSGROHDOQWLRQ**
  - The learning models used in this study were based on the technological tools.
  - An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.

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**Table 1: Summary of the STEM-based 5E inquiry learning model**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary of pedagogical function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement</td>
<td>The teacher or a curriculum task accesses the learners’ prior knowledge and helps them become engaged in a new concept through the use of short activities and facilitate the construction of prior conceptions.</td>
</tr>
<tr>
<td>Exploration</td>
<td>Exploration experiences provide students with a common base of activities within which current concepts (i.e., science and mathematics) and additional activities are exemplified and given to the participants.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>The teacher or the curriculum task accesses the learners’ prior knowledge and helps them become engaged in a new concept through the use of short activities and facilitate the construction of prior conceptions.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Learners explain their understanding of the concept.</td>
</tr>
<tr>
<td>Reflection</td>
<td>The teacher challenges and extends students’ conceptual understanding and abilities and provides opportunities for them to design and construct new ideas, explore questions and possibilities, and organize students’ thinking towards the learning outcomes of current activities.</td>
</tr>
</tbody>
</table>

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**Source:** Bybee et al. (2006. p. 2)
The effectiveness of a STEM-based 5E inquiry learning PD program

In this section, we explore the findings of the study, focusing on the quantitative and qualitative data. The qualitative data was subjected to content analysis, while the quantitative data was analyzed using descriptive and inferential statistics. The findings are presented in two tables, Table 3: Results obtained from t-test for paired samples and Table 2: Overall composition of pre-and in-service teachers.

Table 2: Overall composition of pre-and in-service teachers

<table>
<thead>
<tr>
<th>Participants</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>3UVHULYLFH</td>
<td>10</td>
<td>12.8</td>
</tr>
<tr>
<td>,QVHULYLFH</td>
<td>68</td>
<td>87.2</td>
</tr>
<tr>
<td>7RWDO</td>
<td>78</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 3: Results obtained from t-test for paired samples

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
<th>t</th>
<th>ρ</th>
<th>Δ*</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Mean</td>
<td>SD</td>
<td>n</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>78</td>
<td>72.22</td>
<td>11.44</td>
<td>78</td>
<td>96.72</td>
<td>7.18</td>
</tr>
</tbody>
</table>

The findings indicate a statistically significant improvement in the post-test scores compared to the pre-test scores. The effect size is large, suggesting a substantial improvement in the teachers’ knowledge of electric circuits.
In-service teachers gained an enhanced knowledge and understanding of the two terminals of a light bulb, after the exploration and explanation phases, participants had realized that one is a terminal of a bulb, as indicated in the following reflections:

"Black" base was one of the points which conduct electricity. Before class, I thought that the black light bulb was a conductor. However, after the exploration phase, they now knew that the "black" base was indeed an insulating material as indicated by the following direct quotes:

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Qualitative Analysis

The Inquiry Learning Model indicated the emergence of the following three themes:

Enhanced Knowledge on the Content Used

While the participants have learned about the electric circuit in their earlier science education at school and college levels, many were not aware of the two terminals of a light bulb, located at the metal tip of base and metal around the base, as shown in Figure 1. Instead, they thought that one is a terminal of a bulb, as indicated in the following reflections:

The results of participants that resoundingly supported the conceptualized Inquiry Learning Model, thematic analysis was used as the main method of data analysis. The analyses of the participants' self-perceived written reflections (Braun and Clarke, 2006). Underneath each theme that emerged would be examples from the written self-reflections (Braun and Clarke, 2006). Underneath each theme that emerged would be examples from the written self-reflections (Braun and Clarke, 2006). Underneath each theme that emerged would be examples from the written self-reflections (Braun and Clarke, 2006).

Table 4: Results obtained from independent samples t-test

<table>
<thead>
<tr>
<th>Test</th>
<th>Pre-service teachers</th>
<th>In-service teachers</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>3UWWVHVW0</td>
<td>16.40</td>
<td>10</td>
<td>71.73</td>
<td>9.37</td>
</tr>
<tr>
<td>3RVWWHVW</td>
<td>9.37</td>
<td>68</td>
<td>96.90</td>
<td>6.88</td>
</tr>
</tbody>
</table>

Figure 1: Structure of an electric bulb. Source: https://educationwithfun.com/course/view.php?id=55&section=7
Empowered Pedagogical Skills on STEM-based 5E Inquiry Learning Model

Participants reflected that the professional development resulted in empowered pedagogical skills in using the 5E Inquiry Learning Model.

(Participant #20)

"Empowered pedagogical skills on STEM-based 5E Inquiry Learning Model..."

(Pariticipants #20)

Empowered Pedagogical Skills on STEM-based 5E Inquiry Learning Model

Participants reflected that the professional development has an impact on the pedagogical skills of the participants. For instance, Participants #20 stated, "Empowered pedagogical skills on STEM-based 5E Inquiry Learning Model..."

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ACKNOWLEDGMENT

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