Exploring 3-5 Grade Teachers' Self-efficacy with Inquiry-based Science Instruction

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Cover Page Footnote
Mentor: Dr. Dena Harshbarger, Department of Teacher Education

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EXPLORING 3-5 GRADE TEACHERS' SELF-EFFICACY WITH INQUIRY-BASED SCIENCE INSTRUCTION

Sarah Laden
Mentor: Dr. Dena Harshbarger, Department of Teacher Education

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ABSTRACT

From an early age, teachers should expose students to high-quality STEM education to allow them to explore and discover phenomena. In order to prepare students, teachers must be able to assist students and facilitate the inquiry process. Unfortunately, elementary teachers often have low self-efficacy regarding inquiry-based science and resort to instruction that is not supported by research. A survey was given to third through fifth grade teachers at a small, suburban, mid-western school district to measure their self-efficacy regarding inquiry-based science. The teachers responded to questions that asked them to rank themselves on several skills that are required to teach inquiry-based science. The teachers also shared short-answer responses regarding the adoption of a new science curriculum. These responses indicated that the teachers felt that they needed more time to implement the new curriculum effectively. Overall, the teachers tended to have high self-efficacy, but their responses revealed a need for additional training and professional development. Subsequent training should be frequent, grade-level specific, and allow for open conversation. Districts should also be flexible in implementation in order to relieve pressure and allow teachers to focus on student understanding rather than the systematic completion of lessons.

Keywords: STEM, self-efficacy, inquiry-based science, professional development, elementary science

Due to the importance of science in the world, it would appear that science should be emphasized in all grades. According to the Committee for STEM Education “basic STEM concepts are best learned at an early age—in elementary and secondary school—because they are the essential prerequisites to career technical training, to advanced college-level and graduate study, and to increasing one’s technical skills in the workplace” (2018). In elementary science, inquiry skills should be valued over fact knowledge, so students should explore rather than participate in rote memorization (Bhattacharyya, Volk & Lumpe, 2009). The literature review reports that teachers often misunderstand or underuse inquiry-based science due to lack of information or support. (Deleted Words) This paper examines the self-efficacy of third through fifth grade teachers to discover how teachers feel about inquiry-based science and then offers suggestions to better equip teachers to provide science instruction.

LITERATURE REVIEW

Inquiry-based Science
Inquiry-based science varies from traditional lecture-based teaching, since the students participate in a hands-on investigation in order to learn a science concept. Traditional science instruction for elementary students often includes relying solely on textbooks and worksheets (NGSS, 2016). Inquiry-based science leads to student engagement and teaches critical thinking, communication, collaboration, and creativity (Booker-Chitman & Kopp, 2013). Questions drive the investigations, which have the goal of revealing a science concept. The questions allow the students to actively learn, rather than passively listen. Teachers also encourage students to formulate and ask questions that arise along the way as they take part in the investigation. (McGough & Nyberg, 2015).

**Self-efficacy: A challenge associated with using inquiry-based instruction**

Although inquiry-based lessons are more effective than traditional lecture-based teaching (Cakir, 2017; Akatamış, 2016), they can be difficult to implement for various reasons (Johnson & Dabney; 2018; Bhattacharyya et. al., 2009; Fitzgerald, Danaia, & McKinnon, 2019). One of the primary reasons for teachers not using inquiry-based instruction stems from teachers’ lack of self-efficacy and limited previous background experience (Meyer, Tabachnick, Hewson, Lemeberger & Park, 1999 as cited in Abell & Lederman, 2007). Bandura (1986) defines self-efficacy “as people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses” (p. 391).

A teacher’s belief about their science ability could lead to a dislike for science. This dislike could potentially cause the teacher to teach science less often (Riggs, Enochs & Posanski, 1989). Therefore, in order for teachers to be effective, they must possess high self-efficacy. Self-efficacy can influence how teachers approach science instruction. Holzberger, Phillipp and Kunter (2013) found that high-efficacious teachers “showed higher instructional quality, as indicated by the three dimensions of cognitive activation, classroom management, and individual learning support, whether instruction was rated by the teachers themselves or by their students” (p. 782). In an earlier study (1994) that compared low-efficacious pre-service teachers to their high-efficacious counterparts, researchers found that high-efficacious teachers used more student-centered, hands-on activities, while low-efficacious teachers relied on reading from the textbook (Czerniak & Schriver). High-efficacious teachers were more concerned with student learning, while low-efficacious teachers cared more about student behavior.

**Amplify Science Curriculum**

Amplify is a science curriculum that is intended to provide scaffolding for teachers as they learn to teach inquiry-based science and help grow K-5 students’ scientific interests, knowledge-base, and skills. Amplify Science was built for the NGSS standards and follows a “Do, Talk, Read, Write, Visualize” model (“Our Approach,” 2019). Amplify “blends best practices in both literacy and science instruction to develop students capable of clearly articulating claims and building increasingly sophisticated arguments orally and through writing” (The Lawrence Hall of Science, 2019, p. 11). Since self-efficacy can potentially impact teachers’ use of science instruction and/or curriculum, this study focused on the following questions.
RESEARCH QUESTIONS

- What is the self-efficacy level of 3-5 grade teachers regarding inquiry-based science?
- How do teachers feel about adopting and implementing the Amplify Science Curriculum?

METHODS

Instrument

To answer these questions, researchers used a previously piloted survey (Hodges, Gale, & Meng, 2016). This survey was IRB approved (IRB #052019-4). Different researchers previously used this survey with eighth grade teachers who were implementing a robotics curriculum called SLIDER. There were fourteen questions that asked the teachers to rank themselves on a scale from zero (meaning cannot do at all) to ten (certain can do). Each of the questions was an “I” statement regarding inquiry-based science. There were two questions each for certain elements of an inquiry-based program. These elements specifically came from the SLIDER curriculum, but they align with any inquiry-based curriculum. The elements included the following: (a) add to your understanding; (b) explain; (c) explore; (d) facilitation; (e) organize the challenge; and (f) share. Then, there were four text-based questions asking the subjects how they felt about the new curriculum that they would begin in the fall. To analyze the data, the researcher identified the mean, standard deviation, and variance for each of the questions. The researcher found the mean, standard deviation, and variance for all participants' scores.

Participants

The Qualtrics survey was sent through email to 60 third through fifth grade teachers from a small, suburban, mid-western school district with ten elementary schools. This school was chosen due to its proximity to the researchers, its size, and the fact that the district was changing from one science curriculum to another in the fall. The teacher participants were given the option of entering a raffle for a $50 gift card. Their information was kept separate from their survey answers. No identifying markers were retained. The researchers received thirteen responses.

RESULTS

Quantitative Data

As shown in Table 1, the questions that had the lowest averages were Statement/Question One (I can help my students formulate science questions and investigations when beginning a new, real-world challenge) with an average of 7.38 and Statement/Question Four (I can help my students identify and extract critical information from a given challenge, scenario, or observation of phenomena) with an average of 7.54. Both questions pertain to the element of “organizing the challenge.” Question One had a standard deviation of 1.50 and a variance of 2.26, showing a difference in aptitude. Question Four had a standard deviation of 0.97 and a variance of 0.94.
Table 1. Lowest Average Statements/Questions

<table>
<thead>
<tr>
<th>Statement/Question</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can help my students formulate science questions and investigations when beginning a new, real-world challenge.</td>
<td>7.38</td>
<td>1.50</td>
<td>2.26</td>
</tr>
<tr>
<td>4. I can help my students identify and extract critical information from a given challenge, scenario, or observation of phenomena.</td>
<td>7.54</td>
<td>0.97</td>
<td>0.94</td>
</tr>
</tbody>
</table>

As shown in Table 2, Statement/Questions Five (I can help my students engage with and learn from each other when they share the results of their investigations) and Fourteen (I can help my students present the results of their investigations to the class with posters or other media) had the highest averages of 8.85. Statement Five had a standard deviation of 0.99 and a variance of 0.97. Both of these questions regarded the teachers’ ability to help their students share their data. Number Fourteen had a standard deviation of 1.14 and a variance of 1.31.

Table 2. Highest Mean Score Statements/Questions

<table>
<thead>
<tr>
<th>Statement/Question</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. I can help my students engage with and learn from each other when they share the results of their investigations.</td>
<td>8.85</td>
<td>0.99</td>
<td>0.97</td>
</tr>
<tr>
<td>14. I can help my students present the results of their investigations to the class with posters or other media.</td>
<td>8.85</td>
<td>1.14</td>
<td>1.31</td>
</tr>
</tbody>
</table>
Table 3 shows all of the mean scores, standard deviations, and variance for all the rated statements/questions.

Table 3. Mean, Standard Deviation, and Variance for Rated Questions.

<table>
<thead>
<tr>
<th>Statement/Question</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.38</td>
<td>1.50</td>
<td>2.26</td>
</tr>
<tr>
<td>2</td>
<td>7.85</td>
<td>1.07</td>
<td>1.14</td>
</tr>
<tr>
<td>3</td>
<td>8.23</td>
<td>0.83</td>
<td>0.69</td>
</tr>
<tr>
<td>4</td>
<td>7.54</td>
<td>0.97</td>
<td>0.94</td>
</tr>
<tr>
<td>5</td>
<td>8.85</td>
<td>0.99</td>
<td>0.97</td>
</tr>
<tr>
<td>6</td>
<td>8.31</td>
<td>0.75</td>
<td>0.56</td>
</tr>
<tr>
<td>7</td>
<td>8.08</td>
<td>0.86</td>
<td>0.74</td>
</tr>
<tr>
<td>8</td>
<td>8.38</td>
<td>1.33</td>
<td>1.76</td>
</tr>
<tr>
<td>9</td>
<td>8.46</td>
<td>1.05</td>
<td>1.10</td>
</tr>
<tr>
<td>10</td>
<td>8.62</td>
<td>0.96</td>
<td>0.92</td>
</tr>
<tr>
<td>11</td>
<td>8.08</td>
<td>0.94</td>
<td>0.91</td>
</tr>
<tr>
<td>12</td>
<td>7.83</td>
<td>1.03</td>
<td>1.06</td>
</tr>
<tr>
<td>13</td>
<td>7.92</td>
<td>1.12</td>
<td>1.24</td>
</tr>
<tr>
<td>14</td>
<td>8.85</td>
<td>1.14</td>
<td>1.31</td>
</tr>
</tbody>
</table>

Table 4 shows the overall mean, standard deviation, and variance for all thirteen subjects. Please note that subject one (S-1) did not answer Statement/Question twelve. Subject twelve (S-12) had the lowest survey average of 7.36; subject six (S-6) had the highest survey average of 8.93. Overall, the subjects had an overall mean of 8.17 on the survey, a standard deviation of 0.50, and a variance of 0.25.

Table 4. Overall Mean, Standard Deviation for Survey Scores.

<table>
<thead>
<tr>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.17</td>
<td>0.50</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Qualitative Data

There were four questions that required qualitative responses. The tables below show the common themes that emerged for each question.

Table 5. Themes that emerged from Question 15

<table>
<thead>
<tr>
<th>THEME 1: Nervousness</th>
<th>“I am feeling a little stressed about using Amplify...”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“I am nervous for the new curriculum. It is heavy on writing and that will be a challenge with my diverse population of students.”</td>
</tr>
<tr>
<td></td>
<td>“With any new program, there is a level of uncertainty...”</td>
</tr>
<tr>
<td></td>
<td>“Nervous.”</td>
</tr>
<tr>
<td>THEME 2: Confidence</td>
<td>“I’m cautious, but feel confident that I will find my groove after a while.”</td>
</tr>
<tr>
<td></td>
<td>“I feel confident with my ability to facilitate student learning in science...”</td>
</tr>
<tr>
<td></td>
<td>“I feel very comfortable facilitating student learning with Amplify.”</td>
</tr>
<tr>
<td></td>
<td>“I am excited to begin Amplfy [sic]....”</td>
</tr>
<tr>
<td></td>
<td>“I am excited about the Amplify resource...I feel more confident my students will learn a LOT more science this year compared to previous years.”</td>
</tr>
<tr>
<td>THEME 3: Supplied Materials</td>
<td>“...It seems like it is much more straight forward compared to FOSS in regards to what questions to ask and giving step by step directions.”</td>
</tr>
<tr>
<td></td>
<td>“...it seems to have the instructional information laid out for teachers. The program seems very rigorous, yet engaging and user-friendly.”</td>
</tr>
<tr>
<td></td>
<td>“All the tools are supplied...”</td>
</tr>
<tr>
<td>THEME 4: Time</td>
<td>“...I know it will take more preparation and time on my part since it is new.”</td>
</tr>
<tr>
<td></td>
<td>“...I imagine it will be a learning process to make all aspects of the investigations run smoothly!”</td>
</tr>
<tr>
<td></td>
<td>“...after getting in the classroom this fall and using the curriculum. I’m sure it will go smoothly over time.”</td>
</tr>
</tbody>
</table>

Table 6. Themes that emerged from Question 17
The last question asked, “What do you need in order to implement Amplify effectively?”
The themes for this question were time, looking at the materials, training, and experience. The most consistent theme for this question was time.

Table 7. Themes that emerged from Question 18

| THEME 1: Time | ● “Time to plan and prepare aside from normal planning time”  
| | ● “time to prepare lessons . . .”  
| | ● “Time . . .”(x 7 responses) |
| THEME 2: Materials | ● “. . .get materials ready.”  
| | ● “. . .exposure to materials.”  
| | ● “. . .study the resource.” |
| THEME 3: Training | ● “. . .more specific grade level training.” |
THEME 4: Experience

- “Additional training...”
- “...experience first hand with students”
- “...hands on experience”

DISCUSSION

Due to the small sample size, suggestions are limited to the school district and schools where the study was conducted. However, this study could be used as a base for larger studies in the future.

As shown in Table Four, the average overall score of 8.17 shows that the teachers tended to have high self-efficacy. The standard deviation was 0.50, showing that the scores did not vary greatly. However, the teachers felt least comfortable with the questions that pertained to the “organize the challenge” element as the overall mean for these questions was 7.46. Question one had a mean of 7.38, and question four had a mean of 7.54. This element is a critical component of inquiry-based science (McGough & Nyberg, 2015). A lack of confidence in this area could pose a problem for implementing inquiry-based science instruction, since it centers on forming questions and extracting data. However, the Amplify resource provides a good deal of structure in this area. This addition may help teachers begin to feel more comfortable with this aspect of inquiry-based science in the future. Additionally, teachers may benefit from professional development and opportunities to design and organize inquiry-based investigations.

The text questions suggest that the teachers feel that they need more time and professional development in order to implement Amplify effectively. Interestingly, the teacher with the lowest average score expressed no nervousness in the text-based answers. Alternately, the teacher with the highest average score did express nervousness. This fact might suggest that since the teacher has a higher self-efficacy, they also are more likely to notice areas of weakness. High-self efficacy can stem from more experience or knowledge. This experience and knowledge may allow a teacher to be more aware of areas of growth. Future studies would be needed to learn more. One teacher expressed concern about the heavy writing element within the curriculum. This piece of the curriculum could cause problems in some classrooms for students with limited English Language and/or students who struggle with written expression. Therefore, professional development should include conversations about differentiation for these elements of the curriculum.

The answers varied greatly for the third text-based question, which asked the teachers to define success with Amplify. Some teachers focused on student understanding, while others defined success as getting through the lessons. One teacher stated that they “don’t know” what success with Amplify would look like, and another teacher did not give an answer. The varying responses for this question might suggest that the teachers are not certain on what success would look like with Amplify. The teachers may benefit from the opportunity to talk to one another and administration about what it looks like to implement the curriculum successfully. If the teachers
all have the same definition of success, it will be easier for them to know what to strive for and they will be united across the district.

Overwhelmingly, the most common theme for the fourth text-response question was *time*. Nine of the 13 (69%) participants shared this same response to the question. This need would align with the NGSS suggestions for implementing an inquiry-based program. The NGSS suggests that a large instructional change should take place over two to three years, and dramatic change should not be expected overnight (The National Research Council (U.S.), 2015). It may help teachers to implement the new curriculum incrementally rather than all at once (The National Research Council (U.S.), 2015).

Overall, teachers may benefit from more professional development and time specifically for them to plan for this curriculum. It appears that the previous training had helped the teachers, but more is needed. This time could be provided during Professional Development Days or Professional Learning Community (PLC) meetings. Trainings should break teachers up by grade level, so trainers can teach specifically about each grade level. In order to alleviate stress and pressure, districts should be flexible with implementation. The emphasis should be put on students making sense of phenomena rather than the systematic completion of lessons (NGSS, 2016). The teachers in this study had overall high self-efficacy, but the data revealed a need for more time to be devoted to planning for inquiry-based science. Also, some teachers were more proficient in certain skills than others, so they benefit from being paired with other teachers who are stronger in certain skills than them. Schools should also encourage new teachers to continue to use the research-based methods that they learned as PSTs. Professional development and continued practice can give teachers the confidence they need to increase their self-efficacy regarding inquiry-based science instruction.

**LIMITATIONS & FUTURE STUDIES**

For this particular study, there was a small sample of 13 responses compared to the 60 teachers who received the survey. Since the survey was done during the summer, the timing could have contributed to the low response number. Teachers could have had reporter bias and reported higher or lower scores than would be accurate. The survey was sent to only one school district, so the responses are central to that school district. The survey did not identify how long teachers had been teaching.

In future studies, the survey could ask more questions about the teachers’ specific backgrounds to isolate more variables. The investigators could also follow up with the teachers and ask them the same questions later in the year to see if their self-efficacy has changed over time. It may also be beneficial to do follow-up interviews with the subjects to attain more specific data. The same survey could be given either to teachers in a different school district with a different curriculum, or to teachers in a different school district with Amplify. Future surveys could be administered during grade-level meetings to ensure a higher response rate.
REFERENCES


APPENDIX

Survey

Instructions: This questionnaire is designed to help us get a better understanding of your confidence for teaching practices related to teaching science. There are no wrong answers. Please indicate your confidence level for each situation described based on your present capabilities and your current school and classroom environment. Thank you for your participation! You have the option of completing a raffle for the chance to win a prize, but you do not need to enter in order to complete the survey. (Elements were not listed on original survey).

1. I can help my students formulate science questions and investigations when beginning a new, real-world challenge. (organize the challenge)
2. I can help my students identify and address their science misconceptions through exploration and reflection. (add to your understanding)
3. I can help my students identify patterns or trends in data from investigations and research they conduct. (explore)
4. I can help my students identify and extract critical information from a given challenge, scenario, or observation of phenomena. (organize the challenge)
5. I can help my students engage with and learn from each other when they share the results of their investigations. (share)
6. I can help my students connect what they have learned to real world situations. (reflect and connect)
7. I can help my students connect evidence they gather during an investigation to the claims they make. (explain)
8. I can let my students struggle with concepts and activities during the learning process, where I refrain from providing immediate answers or solutions. (facilitation)
9. I can help my students solve problems, even if they are solving them differently than I would solve them. (facilitation)
10. I can help my students conduct group investigations with the goal of revealing science concepts. (explore)
11. I can help my students use claims, evidence, and reasoning to discuss science concepts. (reflect and connect)
12. I can help students use the scientific content they learn when supporting their claims. (explain)
13. I can help my students connect science content with their previous investigations, giving scientific meaning to the investigations. (add to your understanding)
14. I can help my students present the results of their investigations to the class with posters or other media. (share)

Text Questions

15. How do you currently feel about your ability to facilitates student learning with Amplify?
16. On a scale of 0 to 10, how would you rate your confidence regarding facilitating student learning with Amplify? On the scale, 0 represents “not confident at all” and 10 represents “completely confident”.
17. How would you define success in terms of implementing Amplify?
18. What do you need in order to implement Amplify effectively?