Identifying teacher understanding of phenomena-based learning after professional development

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Abstract. Although phenomenon-based learning is an important pedagogical approach for science instruction, it is still new for many teachers of science. In this study, teachers have received professional development focused on identifying or creating phenomenon events for use in their classroom to improve student learning. Teachers must also be able to integrate modelling approaches so that their students can develop and refine appropriate scientific models related to the phenomenon being studied. This study will investigate teachers’ understanding of phenomena-based learning and issues surrounding the approach. Analysis of teacher questionnaires and open-ended questions about science and engineering practices and crosscutting concepts revealed understanding (1) Planning and carrying out investigations, (2) Analysing and interpreting data, (3) Constructing explanation and designing solutions, (4) Structure and function. However, teachers need supporting about using mathematics and computational thinking. Additionally, the most comfortable knowledge is connecting phenomena, processes, and events with scientific ideas. However, they have problems with controlling different kinds of response from students; some students may accept the new teaching method, but some students refuse to study by this method. Moreover, they also indicated to sharing the experiences to their profession community.

1. Introduction

Nowadays, most students in schools just wait for the teacher to provide the answer [1]. There are many factors that leads them to be unenthusiastic learners such as conventional classroom, traditional learning system, and irrelevant pedagogies [2-5]. Moreover, most educational institutions too often have concentrated on teaching general knowledge that students can have difficulty implementing to real world contexts [6]. In addition, Students do not comprehend how readings or new concepts fit together to create available for use knowledge for figuring out troubles in the world. When asked why they are using materials and equipment, they often say, “Because the teacher wants me to do,” or “We do labs on Wednesday.” [7].

Refer to the three dimensions that are needed to provide students with a high-quality science education [6]. Dimension 1: Practices - (a) the major practices that scientists employ as they investigate and build models and theories about the world (b) a key set of engineering practices that engineers use as they design and build systems. Dimension 2: Crosscutting concepts - Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. They include patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change. Dimension 3: Disciplinary core ideas - The fundamental ideas that are necessary for understanding a given science discipline.
During the previous several decades, educational research has shown that the traditional lecture (i.e., presenting facts while students sit motionless in their seats, sometimes pretending to be listening) and traditional lab activities (e.g., "Do this," "Measure that," "Record this," etc.) are not functional ways to get students to learn and to retain what they have been taught [1]. After facing those problems, educators and instructors have figured out what are the factors and solutions to solve that difficult situation, so phenomenon-based learning is one of the effective methods.

Phenomenon-based learning provides a shift of focus from understanding the world to perceiving and acting in relation to the world [8], and any observable event that we can use scientific information to explain. This can be either a natural phenomenon (such as the phases of the Moon) or a simple gadget. If it is the latter, it’s best if the students can investigate the gadget themselves [1].

Moreover, there is a widespread belief that students can develop models and explanations over the course of a unit. Examples include solar eclipses, the human body maintaining its internal temperature in extreme environments, the spread of invasive species in an ecosystem, or cars crumpling in crash tests. Phenomenon-based learning can have historical significance, such as the survival of particular species of finches on the Galapagos Islands. It can be about issues of social justice, such as the rise of diabetes or asthma among adolescents who live in poverty-impacted communities. It can be about epic phenomena like tsunamis or everyday occurrences like the spread of small through the air [7].

The process of exploration and discovery is not only the hallmark of phenomenon-based learning but is the essence of science. And it is consistent with the philosophy of the Next Generation Science Standards [6]. Rather than simply memorizing facts that will soon be forgotten, students are doing real science. Students are engaged in collaboration, communication, and critical thinking. They obtain a deeper understanding of scientific knowledge and see a real-world application of that knowledge—exactly what was envisioned with NGSS [1].

The aim of phenomenon-based learning is for students to enjoy figuring out what is going on and be creative and innovative [1], and Students are able to identify an answer to “why do I need to learn this?” before they even know what the this [6]. Moreover, what all anchoring events have in common is that they motivate students to try to explain what is going on. These explanations are elaborated and evidence-based accounts—ones that require young learners to draw upon a wide range of science concepts and to engage in multiple investigations in order to construct narratives and representations for the target phenomenon [7].

Phenomenon-based learning have trained many instructors, especially high school, and middle school teachers. This pedagogy is quite new for many people. Teachers who studied about this method have to bring effective phenomenon or construct their own events to use it in their own classroom to help them improve classroom’s environment and encourage students. Therefore, the researcher investigates the teacher’s understanding about phenomenon-based learning. The investigation is going to help educators narrow issues correctly, and improve the training of phenomenal based learning efficiently.

2. Purpose of the Study
To investigate teachers’ understanding of phenomena-based learning and issues surrounding the approach.

3. Methodology
This semi-quantitative study will concentrate on teachers in Wisconsin, USA who have experienced phenomenon-based learning. To complete this objective, I will employ a survey-based methodology by using questionnaires and open-ended questions. All data will be gathered from 14 science teachers in the State of Wisconsin, United States of America, which is high school teachers (35.7%) and middle school teachers (64.2%)

We first identified three main constructs: (a) teacher comfort with the science and engineering practices and crosscutting concepts since the professional development (b) non understanding content about phenomenon based learning, and (c) opinions of teacher about phenomenon-based learning. Next,
I developed a series of items representing each survey construct. For each construct, I questioned mainly about experience that teachers got from that learning method such as Have you ever used phenomenon-based learning in your class since you have trained about this method?

Survey questions development began with a large pool of questions that each identified as aligning with one of three areas to ensure construct validity. Each item was selected by researcher and phenomenon-based learning scholar and some item was disposed or refined based on the extent to which they were aligned with our areas of inquiry, informed by theoretical framework, suitable, relevant, and useful for answering the research questions. Moreover, the key point of the researcher in this process was to (a) avoid jargon and ambiguous terms (b) remove double-barreled questions, (c) provide mutually exclusive response options, (d) present appropriate context for items, and (e) avoid leading questions.

Gathering the data from the survey, I asked in 2 different ways (Likert-type scale and open-ended questions): in (a) remaining knowledge and (b) nonunderstanding content, participants were employed by rating scales to each item as to how much they valued it, the extent to which they practiced it, and their sense of proficiency in it. Each item was on a five-point Likert-type scale, with 1 representing “strongly not understand,” 5 representing “strongly understand,” with a neutral point at 3. In the last part (c) opinions of teacher, the researcher questioned those participants by open-ended questions, such as What is the weakness aspects in phenomenon-based learning in your opinion? Further analyze and scales development are described in subsequent session.

All close-ended survey responses were analyzed descriptively and displayed in a variety of tables and graphs to allow the researcher to see the patterns in the data. The researcher collaboratively analyzed the displayed data to draw conclusions. The analysis was driven by the research questions (1, 2, and 3)

Open-ended questions were analyzed by using a content analysis approach [10-14] The responses were read through and coded into categories based our research questions. Categories were then grouped for the similarity and final thematic categories were developed. In addition, the open-ended questions were analyzed using a text analyzer, software program, that take data and analyze it for the most commonly used words in the text, which can identify broad categories of responses. After that, the researchers ranked the most popular topic that teachers think to identify what is most concerned about phenomenon-based learning.

4. Findings
The results from the survey responses are presented first. This is followed by our analysis of the open-ended questions.

For the survey question that asked teachers to identify their comfort level with the science and engineering practices and crosscutting concepts, we identified the areas of highest and lowest comfort. Teachers stated that they were most comfortable with practices related to investigating (planning and carrying out investigations, analyzing and interpreting data, constructing explanations and defining solutions) and incorporating the crosscutting concept of form and function. These teachers indicated that they were least comfortable integrating the practice of using mathematics and computational thinking. These results are summarized in table 1.

| The most comfortable dimensions                                      | Percentage of each scale |
|-----------------------------------------------------------------------|--------------------------|
| 1. Practice: Planning and carrying out investigations                 | (5) 42.80                |
|                                                                      | (4) 35.70                |
|                                                                      | (3) 21.40                |
|                                                                      | (2) 0                    |
|                                                                      | (1) 0                    |
| 2. Practice: Analysing and interpreting data                         | (5) 28.57                |
|                                                                      | (4) 64.29                |
|                                                                      | (3) 7.10                 |
|                                                                      | (2) 0                    |
|                                                                      | (1) 0                    |
| 3. Practice: Constructing explanation and designing solutions         | (5) 21.40                |
|                                                                      | (4) 71.40                |
|                                                                      | (3) 7.10                 |
|                                                                      | (2) 0                    |
|                                                                      | (1) 0                    |
| 4. Crosscutting Concept: Structure and function                       | (5) 35.70                |
|                                                                      | (4) 42.80                |
|                                                                      | (3) 21.40                |
|                                                                      | (2) 0                    |
|                                                                      | (1) 0                    |
We took the same analysis approach for the survey question focused on teacher understanding of strategies related to phenomena-based learning. Participating teachers identified that they were most comfortable connecting phenomena to scientific ideas and least comfortable responding to different kinds of responses from students. These findings are summarized in table 2.

Table 2. Non-understanding knowledge about phenomena-based learning.

| The least comfortable dimensions                                      | Percentage of each scale |
|-----------------------------------------------------------------------|--------------------------|
| Practice: Using mathematics and computational thinking                | (5)  7.10                |
|                                                                      | (4)  50                   |
|                                                                      | (3)  42.80                |
|                                                                      | (2)  0                    |
|                                                                      | (1)  0                    |

We then analyzed the responses to the open-ended questions in the survey. The themes identified for each question are described below.

4.1. How have you shared teaching ideas about phenomena-based learning with other teachers?
All participating teachers indicated that they have shared strategies for phenomena-based learning with their colleagues. Moreover, some teachers shared experiences about distribution of the teaching method such as “We have "collaborative learning teams" at my school where we discuss our lessons with other teachers who teach the same content. This is where we, weekly, discuss what we do which does include phenomena-based lessons, etc.”, “Ideas have been shared in our [Collaborative Learning Teams] as well as lesson plans were we have Phenomena embedded.” and “We use this in our common grade level lesson planning and at our vertical professional learning. I have shared it a lot.” Some of the teachers indicated that they also allowed colleagues to observe their teaching.

In addition, some of these teachers have had opportunities to talk about phenomena-based learning through social media with other instructors in other districts. For example, “I shared ideas in a Facebook science teachers group and I have worked with teachers in another district.”, “In collaboration with my department, I have met with teachers from other districts to share my learning from.”

4.2. Based on your opinion, which disciplines are best approached through phenomena-based learning?
Teachers indicated that phenomena-based teaching can be used in any science discipline. They rated physical and life science as equal, with slightly fewer teachers selecting Earth and space science. The findings were shown in table 3.

Table 3. Teacher’s response for the best disciplines for phenomena-based learning.

| Responses     | Percentage (%) |
|---------------|----------------|
| 1. Physical science | 38.4          |
| 2. Life science       | 38.4          |
| 3. Earth science       | 23.0          |

Note. N = 26
4.3. What are the biggest obstacles to implementing phenomena-based learning at your school?

We also asked teachers to report the obstacles to implementing phenomena-based learning in their school. Teachers indicated that Time is the biggest trouble (44.4%). Following this response, the most common responses were getting kids to try (22.2%) and finding appropriate phenomena (22.2%). One teacher also indicated that they had issues with colleagues being unwilling to use this approach. The responses are provided in table 4.

Table 4. The biggest obstacles to implementing phenomena-based learning.

| Responses                          | Percentage (%) |
|-----------------------------------|----------------|
| 1. Time                           | 44.4           |
| 2. Getting kids to try            | 22.2           |
| 3. Finding appropriate phenomena  | 22.2           |
| 4. Staff on their team who are unwilling to use this approach | 5.6 |
| 5. No obstacles                   | 5.6            |

Note. N = 18

5. Conclusion and Discussion

Phenomena based learning plays an important role to students and teachers. It provides a shift of focus from understanding the world to perceiving and acting in relation to the world and any observable event that we can use scientific information to explain.

Results demonstrated that most teachers are comfortable integrating the following science and engineering practices and crosscutting concepts: (1) Planning and carrying out investigations, (2) Analyzing and interpreting data, (3) Constructing explanation and designing solutions, and (4) Structure and function. Some part of this result aligns with previous research on NGSS, which has found that most participants skillful with Planning and carrying out investigations; plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim [9]. On the other hand, teachers need supporting about using mathematics and computational thinking. From the finding, teachers still have problem with mathematics and engineering dimension because the percentage of this is quite low.

The survey also asked teachers to report their comfort with strategies used in phenomena-based learning. A majority of instructors are comfortable with connecting phenomena, processes, and events with scientific ideas. On the other hand, they struggle with controlling different kinds of response from students; some students may accept the new teaching method, but some students refuse to study by this method. Other research has also found the same issue [15,16].

We asked teachers about how they have shared phenomena-based learning practices to their professional community. Interestingly, all teachers have shared experience about phenomena-based learning. Most of them recommended and discussed the teaching method in their school. For example, “We have "collaborative learning teams" at my school where we discuss our lessons with other teachers who teach the same content. This is where we, weekly, discuss what we do which does include phenomena-based lessons, etc.”, “Ideas have been shared in our CLT as well as lesson plans where we have Phenomena embedded.” and “We use this in our common grade level lesson planning and at our vertical professional learning. I have shared it a lot.” Additionally, some instructors used social media to widespread the phenomena-based learning to their professional colleague and others.

The teachers were asked to the best discipline for phenomena-based learning. The findings found that the percentage of 3 mains subjects; life science, physical science, and earth science are similar. However, the most suitable discipline for them is physical science and life science. Furthermore, many
teachers noted that all disciplines have their own way to integrate phenomena to their topics. It is dependent on the instructors. It relates to a research that suggest phenomena suit for all disciplines [7]. The biggest obstacle to implementing phenomena-based learning is not having sufficient time. It can also be difficult to engage students with this type of instruction since it is very different from what they are used to, some teachers noted that their colleagues do not support the teaching method while other teachers indicated that they had the support of their colleagues. The environment in school is an enormous factor to moving teaching phenomena-based learning forward.

6. Implications
This study provides insight into how to best support teachers of science as they engage in new teaching strategies. Based on the results of this study, additional emphasis should be placed on helping teachers integrate mathematics and computational thinking into instruction. In addition, teachers need strategies for getting student “buy in” to authentic instruction that is different from their other schooling experiences. Finally, implementation efforts for new science teaching approaches should include attention to building a professional community within schools.

7. References
[1] Bobrowsky M 2018 Q: How can i make science fun and have students learn more by using phenomenon-based learning? Science and Children, 56 70-3
[2] Dameus A, Tilley D S and Brant M 2004 Effectiveness of inductive and deductive teaching methods in learning agricultural economics: a case study NACTA J. 48 713
[3] Drew S and Thomas V 2018 Secondary science teachers’ implementation of CCSS and NGSS literacy practices: A survey study Reading and Writing 31 2 267-91
[4] Louca L, Zacharia Z and Constantinou C 2011 In quest of productive modeling-based learning discourse in elementary school science. J. of Research in Science Teaching 48 8 919-51
[5] Maxfield J and Morse M 2015 An experimental study of the “individuated” versus the conventional classroom ”recitation” method of teaching simultaneous equations
[6] Merleau-Ponty M 1962 Phenomenology of Perception (London: Routledge & Kegan Paul)
[7] NGSS 2013 Next generation science standards : For states, by states (Washington, District of Columbia: National Academies Press)
[8] Soyemi O B, Ogunyinka O I, and Soyemi J 2011 Integrating self-paced e-learning with conventional classroom learning in nigeria educational system J. of Humanistic and Social Studies 2 119-29
[9] Østergaard E, Lieblein G, Brelant T A and Francis C 2010 Students learning agroecology: phenomenon-based education for responsible action J. of Agricultural Educ. and Extension, 16 23-37
[10] Østergaard E, Dahlin B and Hugo A 2008 Doing phenomenology in science education. A research review Studies in Science Education 44 93–121
[11] Penuel W, Turner M, Jacobs J, Horne K and Sumner T 2019 Developing tasks to assess phenomenon-based science learning: Challenges and lessons learned from building proximal transfer tasks Science Education 103 1367-95
[12] Souto-Manning M, Llerena C, Lugo M, Jessica M, Salas A and Arce-Boardman A 2018 No more culturally irrelevant teaching (Portsmouth, NH: Heinemann)
[13] Suitor D 2002 EDSA-ADEE activities: 'Is PBL a valuable alternative to a traditional learning system" European J. of Dental Educ.: Official J. of the Association for Dental Educ. in Europe 6 139-40
[14] Symeonidis V and Johanna F S 2016 Phenomenon-based teaching and learning through the pedagogical lenses of phenomenology: the recent curriculum reform in finland Forum Oświatowe 28 56
[15] Windschitl M, Thompson, J J and Braaten M L 2018 Ambitious Science Teaching (Cambridge, Massachusetts: Harvard Education Press.)
[16] Xerri M J, Radford K and Shacklock, K 2018 Student engagement in academic activities: a social support perspective The International Journal of Higher Education Research 75 589-605