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ORIGINAL ARTICLE

Thai Science Educators' Perspectives on Students' Prior Knowledge: A Documentary Research

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ABSTRACT

According to constructivist theory, learning is a construction of new knowledge based on prior knowledge. As a consequence, science teachers are encouraged to take students' prior knowledge into account. It is evident in many cases that although students' prior knowledge is often not consistent with scientific knowledge, they may have some potential to be developed. Thus, science teachers should not consider only the limitations of students' knowledge but also its potential. Science educators should model how to advance students' prior knowledge. However, research is lacking in this concern as specifically related to science educators. This research uses a documentary analysis of 78 empirical studies and academic articles to examine the perspectives of Thai science educators regarding students' prior knowledge. The results reveal that Thai science educators tend to perceive and approach students' prior understandings as a learning obstacle rather than as a cognitive resource with which science teachers can work to facilitate students' learning. An implication is that Thai science educators may need to be made aware of their perspectives on students' prior knowledge to appropriately communicate to and model for science teachers.

KEY WORDS: cognitive resource; documentary research; prior knowledge; science educator

INTRODUCTION

The success of educational reform efforts depends heavily on teachers who plan and enact student instruction (Prawat, 1992). Like many countries, central to science education reform in Thailand is the transition from traditionally lecture-based modes of teaching and learning to a more constructivist approach (Dahsah and Faikhamta, 2008) which highlights roles of students as active agents in making meanings based on their prior knowledge and experiences (Yager, 1991). Such a transition is not as easy as it requires a significant change in beliefs on the part of science teachers (Crawford, 2007). As a consequence, research in science education has focused on exploring and facilitating school science teachers' constructivist beliefs and teaching practices, which are often done by university-based science educators. However, little is known about science educators themselves. This becomes a shortcoming in literature, especially in Thailand, because science educators play significant roles in science teacher education for both preservice and in-service science teachers. As Faikhamta and Clarke (2013) point out, it is important that science educators demonstrate constructivist instruction for science teachers, not just simply tell them to do so. It is a modeling role that science educators are expected to play for science teachers (Lunenberg et al., 2007). With limited opportunities where science teachers and science educators can regularly meet and communicate for professional development in Thailand, it is promising that research publications can be another way that science educators provide perspectives on how science teachers can and should use students' prior knowledge in teaching and learning (Hammer, 1996) as a basic premise of constructivist instruction. As a community of practices (Wenger, 1998) where science teachers and science educators are members joining the enterprise of science teaching, they can mutually engage and share repertoire through research publications. This study is the first step of exploring potentials of using research publications as a reading source for science teachers. Using a documentary approach, it aims at examining Thai science educators' published research on their efforts to facilitate K-12 students' conceptual understandings of science with a focus on how such research provides and demonstrates constructivist perspectives on and responses to students' prior knowledge for science teachers as readers. Its results will help inform a direction to science educators doing research on this area.

Background

According to constructivism, learning is not merely filling students' heads with knowledge, but an active process by which students construct meanings based on their individual and social experiences (Yager, 1991). Key concepts are that students have prior knowledge before they start formal science education (Driver et al., 1994) and that such prior knowledge influences subsequent learning (Galili et al., 1993). Ausubel (1968) emphasizes the importance of students' prior knowledge by calling it "the most important single factor"

made during instruction. For example, Otero (2006) found that pre-service science teachers may have a "get it or don't" concept, which limits their evaluation of whether students have any scientific knowledge. Morrison and Lederman (2003) found that although science teachers realized that students may have prior understandings, they "did not demonstrate any evidence of building lessons on their students' pre-instructional knowledge" (p. 861). This was also apparent in Gomez-Zwiep's study (2008). Talanquer et al. (2015) also found that pre-service science teachers tended to take an evaluative approach to students' prior knowledge, instead of an inferential one, so they made few attempts to make sense of students' ideas. When comparing how novice and expert science teachers perceive students' prior knowledge, Meyer (2004) found that the novices tended to view learning as an accumulation of bits of information, so they focused more on finding and filling the gaps in students' prior knowledge. However, the experts viewed students' prior understandings as including a wide range of meanings, so they were able to work with this knowledge. Research consistently indicates that science teachers may not be aware of students' prior knowledge, and even if they are, they tend to perceive it as being an obstacle rather than a resource for learning.

Interestingly, Yang et al. (2014) pointed out that a science teacher's ability to be aware of students' prior knowledge does not significantly correlate to a constructivist view about teaching and learning. Rather, it is significantly related to the extent of their traditional views about knowledge transmission. This suggests that accepting a constructivist view of teaching and learning is not the same as and does not necessarily occur simultaneously with, abandoning a traditional view. These authors note that "the teachers, who thought of themselves as holding a constructivist view, actually did not completely abandon a traditional view" (p. 694). In a sense, this result supports what Prawat (1992) called "naïve constructivism," (p. 357) a status in which science teachers begin to accept a constructivist view while still holding a traditional one. As a result, they may superficially equate activity with learning, believing that "student interest and engagement in the classroom are both a necessary and sufficient condition for worthwhile learning" (Prawat, 1992. p. 371, italic in original). What is also interesting is that science educators may not be an exception – they can hold a naïve constructivism as often as science teachers do. Russell (2012) noted that science educators may, by default, begin with a transmission view. Thus, he went on to suggest; it is necessary for them to carefully and reflectively explore their own views on teaching and learning in the process of moving from transmission to constructivism. Taken together, it can be inferred that science educators, like science teachers, may perceive students' prior knowledge as an obstacle, rather than a resource for learning.

The Issue

Despite abundant research on how science teachers perceive students' prior knowledge, the number of studies addressing this issue with science educators is very limited. Clues can be inferred from self-studies done by science educators themselves, describing the tension between traditional and constructivist views (e.g., Osmond and Goodnough, 2011; Wiebke and Roger, 2014). These self-studies suggest that a traditional view of teaching and learning has not been completely abandoned, even by science educators. In other words, while science educators express their preference for constructivism, and use it as a framework to emphasize the role of students' prior knowledge in learning, they may not demonstrate how such prior knowledge is used in the instructional processes in a concrete way. For example, Faikhamta, a Thai science educator, confesses "dualistic perspectives" in his self-study (Faikhamta and Clarke, 2013). Therefore, when he asked student teachers questions such as "What prior knowledge or misconceptions might students hold about this topic?," "What questions should be asked to elicit students' prior knowledge?," and "Is the instructional strategy appropriate to the topic being taught?" Questions such as "what potentials in students' prior knowledge can be used?" and "How can such potentials be enhanced to be more scientific?" were not documented. Although this lack may imply that science educators perceive students' prior knowledge as an obstacle, a definitive answer is not possible as these self-studies did not focus on the use of students' prior knowledge. Nonetheless, it is reasonable to consider this a shortcoming in science education literature because knowledge of students' prior knowledge is necessary not only for science teachers (Magnusson et al., 1999) but also for science educators (Abell et al., 2009) who are directly responsible for science teacher education (Lederman et al., 1997).

It is, thus, necessary that science educators have an appropriate perspective if they are to be able to effectively prepare science teachers to productively use students' prior knowledge during instruction. According to Berry and van Driel (2012); however, research on the teaching practices of science educators is rare. This is a serious shortcoming. Since science educators are responsible for the quality of science teachers, they serve as role models (Lunenberg et al., 2007). This means that science educators have to model how the teachers should productively cope with students' prior knowledge. While the self-studies cited above are limited in how they address this issue, using the published research of science educators regarding how they respond to students' prior knowledge can be a promising alternative. It is suggested that some science educators, when doing research, often draw on their research to inform teaching practice (Berry and van Driel, 2012). The manner in which they refer to students' prior knowledge has a bearing on how they respond to it through their instruction (Maskiewicz and Lineback, 2013). Moreover, as Hammer (1996) suggests, science education research should provide perspectives on the expansion, refinement, and support of science teachers use students' prior knowledge. Therefore, to make this issue more explicit, particularly in but not limited to Thailand, this study investigates how Thai science educators present their perceptions of students' prior knowledge in their published

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research reports. Here, a research question we aim to address:

1. What are perspectives regarding students' prior knowledge that Thai science educators present, implicitly or explicitly, in their research reports?

METHODS

This study is documentary research (McCulloch, 2004), which aims to "get between the lines, to analyze their meaning and their deeper purpose" (p. 1). In this case, the target documents are research reports about students' prior knowledge of scientific topics, written by Thai science educators conducting research to enhance students' conceptual understandings of science. By the term "science educators" used in this study, we referred to those who authored research or academic articles about K-12 students' prior knowledge and conceptual understandings of science regardless to their affiliations, which can be universities, educational organizations, and schools as they contributed to science education knowledge base in Thailand. Research reports on students' understandings about the nature of science were not included as this research area is quite new in Thailand. The main purpose is to examine how Thai science educators perceived students' prior knowledge and presented their views either explicitly or implicitly through their published research. This study is qualitative by nature since it focuses on making interpretations and inferences on Thai science educators' perspectives based on their written research reports.

Targeted Documents

To collect targeted documents, criteria were established to determine which research reports are included in this study. It is important to note that we decided to focus only on research reports written in Thai as they are accessible to and readable by all Thai science teachers. Therefore, these research reports could possibly provide a role model for Thai science teachers. Research reports published in international journals written in English are not included, because only minority of Thai science teachers has full access to them. This criterion, however, creates a challenge as Thailand has no academic journals with a solely science education purpose yet. Research reports in science education are published, in general, social science or educational journals. For a systematic analysis, therefore, we referred to the Thai-Journal Citation Index (TCI) as a starting point to identify relevant journals. As journals in TCI are ranked into three groups according to certain standards (e.g., peer review by external panels), we focused only on journals ranked in Group 1 to ensure their quality. Using the TCI database, we searched for journals that explicitly include publishing science education research in their purposes, resulting in only one journal titled Journal of Research Unit on Science, Technology and Environment for Learning (free access at http://ejournals.swu.ac.th/index.php/JSTEL). This journal has published scientific and technological research as well as science education research twice a year since 2010. It had no mandates or calls for specific issues in science education. With a deliberate search across each issue until 2018, we found 20 research reports. Among these, we authored one, which was excluded from the analysis. This resulted in 19 research reports.

There are obvious limitations in number to these research articles. A brief analysis of this information reveals that these research articles involved only 38 science educators from three universities – one located in Bangkok and other two located in the northeastern region of the country whose results will have limited ability in generalization to larger contexts of Thailand. A decision was made to expand our set of targeted documents as data. We then used another database called ThaiJo (free access at https://www.tci-thaijo.org), which a systematic collection of Thai academic works in electronics versions developed and sponsored by collaboration among organizations such as the Thailand Research Fund, TCI Centre, National Electronics and Computer Technology Center, and some universities. Using keywords as prior knowledge, prior understanding, and conceptions in search with the term "science" and the term "student," we gained 57 empirical studies and two academic articles, which were published in 17 social science or educational journals during 2002–2018. All of them have a peer-reviewed process. However, most of these studies were done since 2009. Of these 17 journals, 13 were indexed as Group 1 and the remaining as group two in TCI databases. Taken together with JSTEL, we had 78 researches and academic articles from 18 journals as a set of targeted documents to be analyzed in the study. These involved 140 science educators from 14 universities. Of these, two were not from universities, one is a science educator from the Institute for the Promotion of Teaching Science and Technology, and the other is a science teacher from a secondary school.

These published research reports did not provide access to Thai science educators' personal or educational background, only including their names and affiliations. A brief analysis of this information reveals that these science educators worked in all regions of the country except the southern and west regions. Most of them (n = 89) came from the universities located in the northeastern region, 25 from the central region including Bangkok, 14 from the eastern region, and 11 from the northern region. Except for two academic articles which were each authored by one individual, research articles were authored by 2–4 science educators, with an average of 2.5. This indicates a tendency for collaborative work often by graduated students and their advisors. Many science educators mostly graduated students, authored only one research article, while 24 authored more than one research papers. It is also important to note that almost all of the research reports are consistent with what Faikhamta (2016) observed in Thai educational research. Specifically, the researchers "attempt to prove the causality of their teaching strategies or teaching techniques," (Faikhamta, 2016. p. 142) underlying what is called the process-product paradigm in educational research whose goal was "to discern the links between teaching processes and the kinds of student achievement" (Shulman, 2004. p. 370). An exception is a few studies that are exploratory. Due to limited access to science educators' backgrounds, we do not analyze their individual perspective on students' prior knowledge. Similar to Smith et al. (1993), we used each research report as a unit of analysis to evaluate the assertions it made about students' prior knowledge.

Document Analysis

To analyze each targeted document, we began by developing an operational definition for each perspective on students' prior knowledge (i.e., obstacle and resource) according to its nature as suggested in the science education literature. In doing so, we found a framework by Smith et al. (1993) is helpful as an analytical guide for the first research question. For the obstacle perspective, we defined it as a description that science educators refer to students' prior knowledge in their research reports as problematic or undesirable because it can make learning harder or slower. Therefore, it needs to be challenged and replaced by scientific knowledge. In addition, contexts or situations in which such prior knowledge is framed by students are not seriously discussed. While students' prior knowledge is multifaceted as it contains both problematic and productive aspects in subsequent learning, the obstacle perspective emphasizes only the problematic aspects being labeled as the misconceptions that hinder learning and therefore need to be removed. Oppositely, we defined the resource perspective as a description the science educators refer to students' prior knowledge as it contains some potential or productive aspects which can be valued and used in teaching and learning in some ways. In this, science educators do not aim to challenge such prior knowledge but focus on contexts to which it is applied and how it can be extended to new contexts. It aims to enhance such prior knowledge's explanatory power (Mortimer et al., 2014). As this is easier said than done, at least one concrete example of analyzing and identifying potentials within students' prior knowledge is required for that each research report is classified as having a resource perspective. With a concrete example as a criterion, the two perspectives are distinguishable.

To validate science educators' perspectives, we decided to consider how they respond to such prior knowledge as they analyze data about students' thinking. In doing so, we followed Talanquer et al. (2015) detailing two different ways in which science teachers can approach students' prior knowledge (i.e., evaluative or inferential). For the evaluative approach, we defined it as a description that science educators evaluate students' prior knowledge based on its alignment with scientific knowledge. For example, a set of categories (e.g., scientific understanding, partial understanding, and misunderstanding) are used to assign a student's response to the question science educators ask. Besides a focus on the correctness and wrongness of the students' prior knowledge, there is no evidence that other dimensions such as contexts or situations in which such prior knowledge is framed by students are taken into consideration. Oppositely, we defined the inferential approach as a description that science educators make sense students' initial thinking as they respond to science educators' questions. It aims not to evaluate, but to find ways to work with that thinking to reach scientific knowledge. As a criterion for the inferential approach, there must be at least a concrete example that science educators analyze and describe potentials or productive aspects in students' responses in the research reports. Based on previous research with science teachers (e.g., Meyer, 2004), it is assumed that science educators with an obstacle perspective tend to use the evaluative approach, while those with a resource perspective tend to use the inferential approach.

We began the data analysis by reading each targeted document to understand its research purposes. Once the research purposes were explicated, we examined whether there is an explicit or implicit reference to constructivism as a theoretical framework within it. This was done to ensure that science educators endorsed constructivism in doing research. We then focused on perspectives on students' prior knowledge that science educators communicate to their audiences according to the operational definitions (i.e., obstacle or resource). This was validated with the actions described by science educators manipulating data about students' thinking in their research using the operational definitions (i.e., evaluative or inferential). In doing so, we emphasized concrete examples that science educators provide in their research reports as key criteria for a resource perspective and an inferential approach. All analysis was done in Thai by each of us individually to capture the texts' cultural meanings. Once results emerged, each of us created and then shared assertations. Then, both of us checked and discussed any discrepancies among the assertations until consensus was achieved. Afterward, we translated the coded texts and the results into English for an impartial science educator, fluent in both Thai and English, to recheck and translate back into Thai to minimize bias. It is important to note that it is impossible to refer to all targeted documents in this article, so only some illustrative examples are cited. A list of all targeted documents can be found in the appendix.

Limitations

While this study revealed a tendency about Thai science educators' perspectives on prior knowledge based on 78 targeted documents, it has obvious limitations, which need to be mentioned before the results will be presented. First, there are a small number of research reports and academic articles published only in some journals by a limited number of Thai science educators. Therefore, it is important to make a caution that the results of this study cannot be generalized with all Thai science educators. Second, this study only uses published research reports and academic articles as documentary data, which may not reflect the complexity of perspectives possessed by Thai science educators whose research reports are reviewed in the present study. Moreover, each individual science educator authoring the same publication may not necessarily share the same perspective. Thus, other data collection methods such as questionnaires, interviews, and classroom observations with direct contact to science educators may provide more access to their perspectives regarding students' prior knowledge in detail.

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RESULTS

This documentary research examines 78 documents concerning students' prior knowledge in Thailand. These documents were written in Thai and by Thai science educators who are assumed to be role models of how Thai science teachers can and should perceive and respond to students' prior knowledge (Lunenberg et al., 2007). Of these 78 targeted documents, 42 explicitly refer to "constructivism" when presenting the importance of students' prior knowledge in learning. Although not explicitly using the term "constructivism," 30 mention students' knowledge construction, a key premise of constructivism. The remainders only cite constructivist literature without a direct reference to constructivism or knowledge construction in the reference. It can be inferred, therefore, that science educators authoring these documents use or, at least, endorse constructivism as a theoretical framework while conducting research on students' prior knowledge. This is not surprising given that constructivism has become central of science education reform in Thailand (Dahsah and Faikhamta, 2008). It is also important to note that these science educators sometimes are inconsistent, referring to students' prior knowledge with different terms (e.g., misconception, alternative conception, prior knowledge, or prior understanding) without the justification of their uses. Therefore, in quoted excerpts hereinafter, we will include the terms originally used by them. However, we will simply use the term "prior knowledge" when discussing these terms in general.

A Majority of Thai Science Educators Convey an Obstacle Perspective on Students' Prior Knowledge

Either explicitly or implicitly, 45 of 78 targeted documents analyzed in this study convey a perspective that students' prior knowledge is an obstacle for learning. This is especially apparent in the introduction sections, where science educators justify why they decided to employ some particular instructional interventions. It also occurs in the discussion sections, where they describe the effectiveness of those instructional interventions. For example, Nakasenee et al. (2015) explicitly note that "if that (students') conception differs from scientific conception … this will be an obstacle to new learning" (p. 72). Similarly, Bootvisate et al. (2015) reported that if students hold a misconception, it is difficult to achieve the purpose or goal of a learning process. Moreover, while some science educators express a constructivist view of learning, describing learning as a process of knowledge construction, they still believe that misconceptions make the process of knowledge construction difficult for students. For example, Juntana and Wuttiprom (2015) noted that "developing a scientific conception on the part of students is hard. Most students have alternative conceptions … and those alternative conceptions result in students having difficulty in constructing new knowledge" (p. 2). Furthermore, Muangramun and Pitiporntapin (2013) noted that "if students have alternative conceptions that are not consistent with scientific conceptions, (it) will make knowledge construction harder" (p. 44). Moreover, some go on to emphasize other negative consequences of misconceptions by students. For example, Jaisuk et al. (2010) noted that "having a misconception, which may occur before or during instruction, results in students either failing examinations or passing with low scores. (They) can be disappointed by classes and have negative attitudes toward the subject" (p. 86). By analogizing students with alternative conceptions with patients with a kind of diseases, Kamtet (2017) notes that.

> In coping with students' alternative conceptions, first teachers need to know or be able to identify what those alternative conceptions are.… Similar to a diagnose by a doctor, if the doctor correctly diagnoses, she can cure relevantly. In opposition, if wrongly diagnosing, a cure will be wrong accordingly. This will not only cure but also may have negative impacts on the patient (p. 55).

According to Smith et al. (1993), research that holds an obstacle perspective on students' prior knowledge often misses the continuity between students' prior knowledge and scientific knowledge. It is evident in many of the targeted documents that science educators do not discuss how students' prior knowledge can be advanced toward scientific knowledge. Rather, they simply state that students' learning difficulties are caused by their misconceptions. This is done to justify their belief that the traditionally transmission modes of teaching and learning (i.e., lectures and tutoring) are not sufficient. For example, Supasorn et al. (2016) noted that "changing students' alternative conceptions is hard. Showing correct information that contradicts students' alternative conceptions may not be enough to make them change their ideas... Thus, there must be a variety of appropriate learning activities to lead students' alternative conceptions toward more correct ones" (pp. 30-31). Similarly, Siri et al. (2015) suggested that "students' misconceptions will not disappear if (they) are not taught rationally.… students have to be made aware of their misconceptions by confronting and correcting (them)" (p. 206). More explicitly, Kuhapensang et al. (2013) pointed out that "alternative conceptions are a real problem that should be solved.… Alternative conceptions are important obstacles to developing scientific understanding … When an alternative conception occurs, it is hard to change it through traditional instruction" (p. 101). In a sense, these texts urge the establishment of new or different instructional interventions for dealing with students' misconceptions more effectively.

A minority of science educators in this study tend to present ways of using students' prior knowledge in teaching. For example, Sreebua et al. (2015) reported that "the teacher asks questions to elicit students' prior knowledge, so the teacher is aware of what kinds of prior knowledge each student has. Then, the teacher encourages the students to ask questions (and) identify problems to be studied, which may come from (their) curiosity or be relevant to their prior knowledge" (p. 151). In a similar vein, Khongton et al. (2016) noted that "instruction begins with creating models to elicit students' prior or basic knowledge. In so doing, the students design a model, first in small groups and then with the whole class, leading to testing that model" (p. 65).

Furthermore, Bootvisate et al. (2015) stated that "each student predicts a model according to their basic understandings by drawing a picture.… (Then, students) exchange their models with friends. This can lead to a hypothesis (as they) compare and contrast theirs and others" (p. 161). In a sense, these texts suggest that science educators might perceive students' prior knowledge as a cognitive resource for using to guide subsequent inquiry. However, in writing the texts, these science educators describe the steps of their instructional interventions (i.e., 7Es inquiry and model-based instruction) only in a theoretical manner. They do not concretely demonstrate what specific prior knowledge expressed by students and how such prior knowledge is productively used in the instructional processes even in the discussion section of their studies. Since our operational definitions require a concrete example, these texts are not coded as a resource perspective.

A Majority of Thai Science Educators Respond to Students' Prior Knowledge in an Evaluative Manner

Thai science educators who view students' prior knowledge as an obstacle to learning are likely to use an evaluative approach. This is especially apparent when they collected and analyzed data in their research. Except the targeted documents that are exploratory studies (Seekuancha and Pimthong, 2013; Nakasenee et al., 2015; Burana and Dahsah, 2017) and academic articles (Sangpradit, 2015; Kamtet, 2017), the remainders, which is a majority, examine the effectiveness of some particular instructional intervention(s) using quasi-experimental methodology, mostly employing one-group pre-test and post-test design. This also confirms what Faikhamta (2016) noted about a tendency in Thailand's educational research that the researchers "attempt to prove the causality of their teaching strategies or teaching techniques" (p. 142) with students' learning outcomes. By conducting research in this way with an underlying perspective on students' prior knowledge as an obstacle, a majority of science educators are more likely to approach students' prior knowledge in an evaluative manner. They are inclined to use content-free, pre-determined categories to evaluate students' prior and subsequent knowledge even though qualitative data were collected via interviews or two-tier questionnaires. For example, Kuhapensang et al. (2013) categorize students' knowledge into five groups—scientific understanding, partial understanding, partial understanding with specific misconception, specific misconceptions, and no understanding. They focus on classifying students into each of these ordered categories without attempts to identify productive aspects in students' responses even those classified as "partial understanding."

An evaluative approach to students' prior knowledge is more apparent in the targeted documents that use a framework with fewer pre-determined categories to analyze qualitative data. For example, using a two-tier instrument, Siri et al. (2015) categorize students' responses into 3 groups (i.e., good conception for correct responses in both multiple-choice and written parts, alternative conception for one correct response in either part, and misconception for incorrect ones in both parts). While describing students' alternatives and misconceptions at the end of their research report (e.g., "students are unable to construct the ionic formula … due to the use of Roman numerals to indicate the charge on representative elements"), they do not identify productive aspects in students' responses. In a similar vein, Supasorn et al. (2016) use a conceptual test which consists of two parts— a check-list format and a drawing format. They then categorize the data regarding students' responses into 3 groups (i.e., sound understanding, alternative understanding, and misunderstanding). Similar to Siri et al. (2015), this group of science educators focuses on reporting learning gains made by students after instruction, as well as on the comparison of students' representative drawings in each category. They do not discuss any productive aspects of those not categorized as sound understandings. Even more roughly, Promso et al. (2015) evaluate students' responses as either correct or incorrect in order to report their learning gains and the increasing number of students who gave correct answers. It is clear that these science educators use an evaluative manner in approaching to students' prior knowledge in their research reports.

While most science educators use a content-free categorizing framework in analyzing qualitative data in their research, a few use a content-specific one, so they are more able to make inferences about students' prior knowledge. For example, Nakasenee et al. (2015) and Chalermchat and Wuttiprom (2015) use open-ended surveys to explore students' prior knowledge about acids and bases and about force and motion, respectively. Although both groups still use pre-determined frameworks, as do most of the science educators previously mentioned, content-specific frameworks allow them to analyze and describe students' knowledge more specifically. Nonetheless, they focus on describing what students do not know or misunderstood without identifying productive potentials in their responses. Even in a case that students expressed partial understandings, some focuses only on negative aspects and ignores productive ones. For example, in their study about students' understanding of work and energy, Thawachmethee et al. (2015) note a student's response that "to do work is to have a force acting on an object that makes it move for a distance" (p. 223). They classified this response as a "misunderstanding" even though it, according to our point of view, has potentials as it implies that this student understands a relationship among work, force, and distance. As a consequence, there is a lack of concrete evidence that these science educators demonstrate how they analyze students' prior knowledge to identify its potentials, which is a key criterion for an inferential approach. Without this, a cognitive resource in students' prior knowledge is not noted in their research.

One may argue that a research methodology used (e.g., quasi-experimental research) can influence science educators to use an evaluative approach to manipulating data about students' ideas as this kind of educational research has been criticized that it often ignores teachers' thinking and intentions during the instruction (Garrison and Macmillan, 1994). However, it is apparent in our targeted documents that such an evaluative approach can be also found in exploratory studies. For example, Seekuancha and Pimthong (2013) note a number of students' alternative conceptions about substances as well as possible factors that might cause the students to have those. However, they do not identify potentials within student's naïve ideas upon which scientific conceptions can be build. By considering students' alternative conceptions as "an obstacle for learning (that) makes knowledge construction hard to occur" (p. 2), they simply suggest that "teachers can use the results of exploring (students') conceptions to design instruction for conceptual change" (p. 8). Also, in the academic articles, science educators focus only on the aspects that students' understandings differ from scientific ones. For example, Sangpradit (2015) note a number of alternative conceptions in physics, which "makes students encounter difficulties in learning" (p. 203). As a consequence, he suggests science teachers to "help students change their alternative conceptions to scientific conceptions by making them see that the conceptions they have are incorrect" (p. 207). Therefore, while a research methodology used by science educators might matter, it is not only one factor that influences them to use an evaluative approach.

A Majority of Science Educators do not Connect their Use of Instructional Interventions to Students' Prior Knowledge in Concrete Ways

In the targeted documents that aims to improve students' conceptions, science educators use a variety of instructional interventions such as inquiry-based instruction (Supasorn et al., 2016), conceptual change approach (Atirattanawong and Termtachatipongsa, 2014), analogy (Buarabudtong and Termtachatipongsa, 2013), model-based instruction (Bootvisate et al., 2015), problem-based learning (Nisaitrong and Poosittisak, 2016), predict-observe-explain strategy (Juntana and Wuttiprom, 2015), metacognitive strategies (Kathinthet et al., 2012), and cooperative learning (Siri et al., 2015). Moreover, some may integrate formative assessment strategies such as exit targets into their use of instructional interventions (Atirattanawong and Termtachatipongsa, 2014; Buarabudtong and Termtachatipongsa, 2013). However, the rationales of deciding to use such instructional interventions are not connected to students' prior knowledge in specific ways. By claiming that the traditional, lecture-based modes of teaching and learning are not sufficient to deal with students' misconceptions, which are often resistant to change, many simply point to some instructional approaches or strategies, which are more constructivist than traditional instruction without presenting what students' prior knowledge is and how such constructivist approaches or strategies would build on that prior knowledge. It seems that such instructional intervention is pre-determined with no or little attempts to make sense of students' prior knowledge in detail. For example, after introducing to a theoretical base and four steps of the conceptual change approach as a constructivist instruction, Atirattanawong and Termtachatipongsa (2014) note that:

> Based on a review of related research and theory, it can be concluded that there are many alternative conceptions, especially on the topic of plant life which its content is difficult and complicated. This makes students easily have alternative conceptions.… Therefore, the researchers are interested in using conceptual change strategies with formative assessment to develop Grade 7 students' conceptions of plant life. (p. 203)

Then, the pre-determined instructional interventions are used to eradicate or change students' prior knowledge or misconceptions as many science educators perceive it as an obstacle to learning the targeted scientific concepts. While their research reports provide positive results in the improvement of students' prior knowledge, science educators often fail to explain such results in detail. In general, they simply explain that such instructional interventions were based on constructivism and/or that the instructor was following the instructional steps. For example, Parinthawong and Termtachatipongsa (2014) note that "students have more correct conceptions because … new conceptions are intelligible, plausible, and fruitful for them" (p. 177). Some science educators went on to say that the instructional interventions help the student connect scientific knowledge with their prior knowledge (Sreebua et al., 2015), which seems to contradict what they previously mentioned in the introduction sections – that students' prior knowledge is not consistent with scientific conceptions. Hence, they seem not to be aware of how these two inconsistent understandings could be connected. It is a discontinuity between students' misconceptions and scientific conceptions that many science educators fail to explain in their research results. Despite the fact that there is a lack of concrete evidence in the research reports illustrating how students' prior knowledge was built on or refined to be more scientific, many Thai science educators recommend that science teachers use their instructional interventions in classrooms. For example, Muangramun and Pitiporntapin (2013) note that:

> The research results show that most students had more scientific conceptions … after model-based learning … Because the students did hands-on activities themselves, searched for additional knowledge from learning media to communicate scientific information about models they constructed … and communicated their thoughts in the forms of drawing models.… The researchers suggested that teachers should be aware of alternative conceptions., which influence students' learning … Moreover, learning activities that let students do hands-on activities themselves, communicate scientific information, and work collaboratively, are effective in helping students to develop scientific conceptions (p. 44).

General recommendations like those contained in the excerpt above often have nothing to do with students' prior knowledge, letting alone building on it.

CONCLUSIONS AND DISCUSSION

Science education literature emphasizes the influence of students' prior knowledge in learning and suggests two

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different perspectives (i.e., obstacle and resource) on students' prior knowledge (Smith et al., 1993). These approaches can influence the ways in which science teachers can approach and respond to students' prior knowledge during instruction. This documentary research examines how Thai science educators perceive and approach students' prior knowledge by analyzing their research reports, which can potentially serve as role models for Thai science teachers. There is a serious shortcoming in science education literature, as a number of research projects have focused on science teachers, not on the science educators who are directly responsible for preparing and developing them. Given that science, educators should provide a role model for science teaching practice (Lunenberg et al., 2007), including how science teachers should respond to students' prior knowledge, a lack of research on how science educators perceive students' prior knowledge can be a limitation in reforming science education. In this documentary research; therefore, 78 targeted documents regarding students' prior knowledge were selected based on certain criteria. The analysis of these documents revealed that Thai science educators perceived students' prior knowledge as an obstacle to learning. They approached students' prior knowledge in an evaluative manner to find students' misconceptions and then employed some instructional interventions to overcome those misconception. Simply put, they aimed to eradicate students' misconceptions and replace them with scientific ones.

Although those instructional interventions had some degree of effectiveness in improving students' prior knowledge, Thai science educators' view of students' prior knowledge as an obstacle to learning seems problematic according to more current viewpoints of the science education community. According to Smith et al. (1993), perceiving prior knowledge as a stable mental entity in students' cognitive structure to be eradicated or replaced is indeed similar to seeing students as blank slates to be filled with knowledge. This reflects a traditional view of teaching and learning. In addition, this perspective contradicts the premise of constructivism, that students' prior knowledge is built on and refined in a process by which students construct new and more advanced knowledge. It is the discontinuity between students' prior knowledge and scientific knowledge that the obstacle perspective fails to explain. As evident in this study, Thai science educators could not provide a clearly explain the cognitive mechanism when students' misconceptions moved toward more scientific knowledge during instructional interventions. Many of them explained that a conceptual change occurs when students feel dissatisfied with their own alternative conceptions as being challenged during the early phase of instruction before they see intelligibility of scientific conceptions to be accepted in later phases. However, Chinn and Brewer (1993) demonstrated that such dissatisfaction does not occur easily as students might reject or ignore discrepant events designed to challenge their alternative conceptions. While many Thai science educators still explain a process of conceptual change in this way, Mortimer (1995) argues that it is "an unreal expectation" (p. 267–268) that students will abandon their initial conceptions and then accept scientific conceptions.

Whereas the notions that students' prior knowledge can differ from scientific knowledge and that such prior knowledge can be an obstacle for subsequent learning are partly true, it is also true that prior knowledge can be a starting point for the students to interpret new experiences in science classrooms. As Pintrich et al. (1993) put it, "prior knowledge plays a paradoxical role in conceptual change.… One is that prior knowledge can impede conceptual change when that knowledge is not veridical.… Yet prior knowledge also forms a framework for judging the validity of new information to be learned and thus forms a procrustean bed for the development of new knowledge" (p. 191). Therefore, only an obstacle perspective on prior knowledge is not enough for science educators to understand the process of conceptual change. Maskiewicz and Lineback (2013) argued that this naïve perspective was "so yesterday" and, in fact, is a misunderstanding of constructivism. In a similar vein, Larkin (2012) suggests that this is a misconception about misconceptions. Nonetheless, Thai science educators seem to not be aware of this problematic aspect in their perspective on students' prior knowledge. This can potentially limit them in perceiving students' prior knowledge in more productive ways as it can be a cognitive resource for learning – a more recent perspective that is promoted by science education communities (e.g., Dekkers and Thijs, 1998; Hammer et al., 2012; Larkin, 2012; Maskiewicz and Winters, 2012). In addition, Thai science educators fail to play a role in modeling constructivist perspectives and practices for science teachers, how to productively use students' prior knowledge.

Although Thai science educators claim that they accept or endorse constructivism, the ways in which they perceive and cope with students' prior knowledge does not totally align with the premise of constructivism. Similar to science teachers in Yang et al.'s (2014) study, Thai science educators might not completely abandon their traditional views on teaching and learning as they are still focused on instructional activities rather than on students' ideas and learning. This result is further supported by Russell (2012), noting that science educators can, by default, begin their professional lives with a transmission view. These Thai science educators might be in the process of transiting from transmission to constructivism. It is a status similar to what Prawat (1992) called "naïve constructivism" in that Thai science educators perceive that activity-based or hands-on instruction is sufficient to eradicate or overcome students' erroneous prior knowledge. They ignore productive aspects of students' prior knowledge as a cognitive resource and do not focus on building on it for more scientific knowledge. Thai science educators whose research reports were analyzed in this study may not be representative of teachers as a whole. However, it can be argued that the obstacle perspective on students' prior knowledge is neither accidental nor uncommon among Thai science educator communities as it can be found in science education literature (Smith et al., 1993). Similar evidence can be found in international research reports written by Thai science educators (e.g., Suppapittayaporn et al., 2010), in which students' prior knowledge tends to be described as problematic or undesirable, with its productive aspects overlooked.

SUGGESTIONS

The results of this research highlight the need for Thai science educators to reflectively explore and then broaden their own perspectives on students' prior knowledge in a way that is better aligned with international science education communities. That is to say, Thai science educators should consider students' prior knowledge as a cognitive resource for learning so that they will be able to identify which productive aspects in it can be built on for more scientific knowledge. Since Thai science educators are role models for science teachers, both preservice and in-service, it is crucial that they demonstrate the productive use of students' prior knowledge. As Thai science educators, we are also beginning a transition, as we attempt to broaden our own perspectives on students' prior knowledge as a cognitive resource and convey this attitude to our science teachers (Ladachart and Ladachart, 2016). Given the fact that there is a lack of professional development for science educators (Johnston and Settlage, 2008) who often have different backgrounds before entering into this career (Berry and van Driel, 2012), we see a self-study as a promising yet practical methodology (Faikhamta, 2016). In this way, science educators can systematically examine their own perspectives on students' prior knowledge and learn how they can approach it and use it productively. As "changes in practice often begin with a willingness to examine beliefs" (Russell, 2002. p. 7), it seems to be necessary for Thai science educators to examine themselves first through a self-study before any formal mechanism supporting their professional development can be systematically established in Thailand.

Once Thai science educators become familiar with perceiving students' prior knowledge as a cognitive resource, they should practice and model how productive aspects in such prior knowledge can be used to build more scientifically advanced knowledge. In these efforts, we consider what Hammer et al. (2012) called "responsive teaching" to be a promising approach. According to them, a responsive approach to instruction is:

> To adapt and discover instructional objectives responsively to student thinking. The first part of a lesson elicits students' generative engagement around some provocative task or situation … From there, the teacher's role is to support that engagement and attend to it – watch and listen to the students' thinking, form a sense of what they are doing, and in this way identify productive beginnings of scientific thinking. In this way, the teacher may select and pursue a more specific target, in a way that recognizes and builds on what students have begun (Hammer et al., 2012. p. 55).

This responsive approach to instruction can be challenging even for experienced science teachers (Maskiewicz and Winters, 2012). Moreover, this responsive approach to instruction seems to contradict the developmental view of teacher professional growth, in that teachers often progress from being concerned about their own survival in classrooms to focusing more on their instructional actions and then onto students' learning, respectively (Fuller, 1969). Nonetheless, research results challenge this view, as they show that even preservice science teachers can learn to be attentive and responsive to students' thinking and prior knowledge when they are supported in these activities (Kang and Anderson, 2015; Levin et al., 2009). Therefore, instead of strictly following pre-determined instructional steps as good instructional practice, Thai science educators should begin to learn and practice a responsive approach to instruction, so that they can be able to model a more constructivist approach to instruction for science teachers.

The results of this research also raise one more important issue regarding essential qualifications for Thai science educators. Whereas this issue has been internationally discussed (Abell et al., 2009; Lederman et al., 1997), characteristics of those who become science educators in Thailand seem to be taken for granted. In general, educators are required to have a masters or even a doctoral degree in science education, with or without experience as science teachers. As noted by Abell et al. (2009), this may not be enough, as science educators should have not only theoretical but also practical experience to prepare pre-service science teachers as well as develop in-service science teachers. As Faikhamta and Clarke (2013) put forward, "if we (as science educators) expect our student teachers to teach in particular ways, we have to teach them in those ways, not just tell them" (p. 973). Therefore, besides various knowledge domains, science educators must also have a truly constructivist view of teaching and learning (Lederman et al. 1997), so that they can demonstrate such a view for science teachers through teaching practice and research practice. Science educators must not only have pedagogical content knowledge for teaching science (Bradbury et al., 2017) but also that for instructing science teachers (Abell et al., 2009). We support all these suggestions by highlighting that identifying productive aspects in students' prior knowledge, and then using them as cognitive resources during instruction, is a necessary indicator for qualified science educators as this practice truly reflects a constructivist mode of science teaching.

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