Pre-service Physics Teachers’ Beliefs about Learning Physics and Their Learning Achievement in Physics

Hong-Jeong Kim
National Science Museum, Yuseong-gu, Daejoen, 34143, Republic of Korea
nsmdrk@korea.kr

Sungmin Im | ORCID: 0000-0001-6547-7027
Corresponding author,
Department of Physics Education, Daegu University, Gyeongsan, Gyeongbuk, 38453, Republic of Korea
ismphs@daegu.ac.kr

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Abstract

This study investigates pre-service teachers’ beliefs about learning physics and explores how beliefs correlate with learning achievement as evidenced by conceptual understanding and grades in a year-long physics course. To investigate beliefs about learning physics, 14 second-year pre-service teachers in a teacher training program in South Korea completed a Likert-style questionnaire called the Beliefs About Learning Physics Survey (BAPS). To measure learning achievement, final grades for the physics course were obtained and the Force Concept Inventory (FCI) was used to assess conceptual understanding. Analysis revealed that pre-service physics teachers’ beliefs about learning physics had a positive correlation with conceptual understanding but not with motivational beliefs. Students’ grades in physics had a positive correlation with cognitive beliefs, regardless of changes in pre- and post-test responses. Implications about how to utilize pre-service physics teachers’ beliefs about learning physics as an epistemological resource for teaching and learning physics are discussed.
1 Introduction

For several decades, intensive studies have focused on students' learning with the aim of improving science education. While many studies have been based on cognitive aspects of learning, there has been increasing emphasis on affective aspects of learning. In many countries, enhancing students' affective domains, such as interests, motivations, attitudes, and beliefs, has been more and more emphasized as a goal of science education. Though many studies have focused on conceptualizing and evaluating such affective domains in the contexts of science learning, recently the affective domain has also been considered an influential variable in science teaching and learning research. Some studies have explored the role of the affective domain in students' learning (Wigfield & Cambria, 2010; McConnell & Kraft, 2011) or suggested a pedagogical approach using affective domains to enhance students' learning in science (Ramma et al., 2018; Alsop & Watts, 2000). Some studies have explored the relationship between cognitive domains and affective domains to explain cognitive processes and conceptual understanding (Scheffler, 1991; Cobern, 1996; Siegel, 1997). For example, Cobern argued that the affective construct plays a role in supporting students' conceptual change.

Beliefs in particular have been suggested as an important research topic in science education, as beliefs have been considered one of the psychological constructs that explain cognitive processes (Chiappetta & Koblla, 1998). Some researchers have considered beliefs about learning to be a greater factor than even interest or attitude (Knein, 1999). Furthermore, there have been an increasing number of studies insisting that students' beliefs might affect the cognitive process of learning (Gallagher, 1991; Songer & Linn, 1991; Lederman, 1992; Ryan & Aikenhead, 1992; Pomeroy, 1993; Hammer, 1994; Redish et al., 1998; Tsai, 1998; Hogan, 1999). Although the definitions and expression of belief differ according to its conceptualization based on different theoretical backgrounds, such as student's expectation, self-efficacy, or epistemological belief, all of these studies have similarly emphasized beliefs as an important construct or mediating factor in learning science.

Despite increasing emphasis on beliefs in the field of science education research, there has been relatively little emphasis on examining the impact of
pre-service science teachers’ beliefs. Studies about pre-service teachers’ beliefs have mainly focused on their self-efficacy or teaching efficacy (for example, Riggs & Enochs, 1990; Martins et al., 2014; Yada et al., 2021). These studies have insisted that pre-service teachers’ self-efficacy beliefs can influence their prospective teaching. However, little has been done to explore to how pre-service teachers’ beliefs about knowledge and learning are distributed and to what extent pre-service teachers’ beliefs play a role in their own learning of science.

Therefore, in consideration of students’ beliefs as an important variable in learning physics, this study aims to investigate pre-service teachers’ beliefs about learning physics and seeks to explore how beliefs correlate with learning achievement, involving such things as conceptual understanding and students’ grades on assignments in physics. For this, we addressed the following research questions:

1. How do pre-service physics teachers’ beliefs about learning physics change during a one-year physics course?
2. How do pre-service physics teachers’ beliefs about learning physics correlate with their conceptual understanding?
3. How do pre-service physics teachers’ beliefs about learning physics correlate with their achievement (grades) in physics?

In this paper we describe the results of an investigation framed by these research questions. In the sections that follow, we review the theoretical background and previous research, detail the research methods, and provide information about the research context and participants. We share the results of this study in two subsections. First, we describe pre-service physics teachers’ beliefs about learning physics, their conceptual understanding, and their learning achievement (grades) during a one-year general physics course. Second, we share findings from analysis of the correlation between pre-service teachers’ beliefs and learning achievement, including conceptual understanding and grade scores. We conclude by discussing the findings and offering implications for our pre-service science teacher preparation.

2 Theoretical Background

2.1 Beliefs in Science Education

According to Brown and Cooney (1982), beliefs are dispositions in action and major determinants of behavior. In learning theory, beliefs are often considered as one’s epistemology, that is, knowledge about knowing and learning. Since Jean Piaget first introduced his theory of genetic epistemology, many studies have focused on students’ epistemology to explain learning processes.
(Burman, 2021). Perry (1968) first studied the role of epistemology in pedagogical content knowledge in an investigation of American Caucasian undergraduates’ epistemological development processes in knowledge and learning. Hofer and Pintrich (1997) reported that there was no consensus on which factors affected belief systems. Ryan (1984) analyzed the correlation between epistemological beliefs and cognitive ability. Using an assessment tool that consisted of sixty-three items based on five dimensions, Schommer (1990, 1993, 1994) showed that some aspects of beliefs had correlation with task performance.

In the field of science education, studies of students’ beliefs have been widely discussed in the context of teaching and learning science. Poole (1995) asserted that beliefs and values played important roles in science and science education and that science teachers and researchers need to be careful of the influence that mental, moral, social, and cultural factors have on beliefs. Hammer (1994a, 1994b) researched the conceptualizing of beliefs about learning and knowledge in learning physics, showing a positive correlation between the two. Tsai (1998, 1999) measured beliefs of middle school students based on Pomeroy’s (1993) study, which consisted of traditional views of science (empiricist views) and nontraditional views of science (constructivist views). Tsai found positive correlation between beliefs, learning motivation, and cognitive beliefs and suggested cognitive beliefs as a factor for intermediating learning through experimentation.

2.2 Beliefs about Learning Physics

Beliefs can be differently conceptualized depending on the philosophical approach, that is, epistemology or psychology. From an epistemological approach, beliefs can be interpreted as one’s idea or view on knowledge and knowing itself. However, from a psychological approach, beliefs can be regarded as a construct representing motivation or expectation of one’s ability to perform some tasks. Because these approaches are fundamentally different, the concept of belief is often used differently according to the context. However, each approach has its own meaning and significance, and to regard beliefs as a two-aspect construct can be an alternative approach in the context of science education.

Im (2001) suggested that beliefs in learning science could be divided into cognitive beliefs and motivational beliefs, which represent the epistemological and psychological aspects of belief, respectively. In his study, Im described cognitive beliefs as being based upon one’s cognition about knowledge and learning in a specific subject matter. He argued that motivational beliefs are based on an expectation about one’s ability and values of learning in specific subject matter. Using this conceptualization of beliefs, Im investigated
students’ beliefs and other variables related to learning physics and statistically analyzed students’ survey responses using structural equations to conclude that both cognitive and motivational beliefs could interplay with each other and affect learning in physics, including conceptual understandings of physics concepts (Figure 1).

Beliefs are also considered to be epistemological resources in the teaching and learning of physics (Hammer, 2000; Im, 2008). Hammer (2000) criticized physics education research as focusing exclusively on student knowledge and argued it is important to consider students’ beliefs about knowledge as an epistemological resource for learning introductory physics. Building from Hammer’s study, Im (2008) explored the role of beliefs about learning physics as an epistemological resource for pre-service physics teachers. In this study, Im suggested the use of instructional approaches, including dialogic strategies to bridge reflective thinking and intuitive thinking, and utilizing inquiry-based experiments in the context of physics teacher education to explore teachers’ beliefs. In another study, Kim and Im (2012) utilized the Beliefs About Learning Physics Survey (BAPS) to explore the relationship between beliefs about learning physics and views on the nature of science through a correlational analysis. They found that the learning dimension of beliefs about learning physics and the process-content dimension of views on the nature of science were highly

![Diagram](https://example.com/diagram.png)
correlated. Although beliefs and other epistemological or psychological variables in learning physics have been considered important variables that affect learning physics, more research focused on how students' beliefs about physics learning have an impact on teaching and learning practice are needed. This study seeks to fill this gap.

3 Research Method

3.1 Participants and Context
The subjects of this study were a group of second-year pre-service physics teachers in a 4-year teacher training program at a college of education in South Korea. Originally, 18 participants volunteered for this study, but only 14 participants completed all surveys necessary for analysis. Among the 14 participants, 13 were male and one was female. In the teacher training program, pre-service physics teachers must study general physics in the first 2 years. In the first year, they learn basic Newtonian mechanics and thermodynamics in Introductory Physics I & II. In the second year, they learn introductory electromagnetism and optics in Advanced Physics I & II. In these courses, students learn about all basic areas of general physics. More advanced physics related to mechanics, electromagnetism, and optics are taught in the 3rd and 4th years of the program.

3.2 Measurement Tools
As descriptive research, the main procedure of this study consisted of collecting and analyzing data from the participants about the following: beliefs about learning physics, conceptual understanding, and student grades in the physics course.

3.2.1 Beliefs about Learning Physics
To investigate pre-service physics teachers’ beliefs, we utilized BAPS (Im, 2001). BAPS is a 4-point Likert-style questionnaire and consists of 36 items distributed among five dimensions. The Knowledge, Learning and Relation dimensions represent epistemological aspects of belief, called cognitive beliefs. The Expectation and Value dimensions represent psychological aspects of belief, called motivational beliefs. The framework and configuration items of BAPS are shown in Table 1 (Im, 2008). In the original study, the reliability coefficient and Cronbach’s alpha of BAPS was reported as 0.88, but in this study, the reliability coefficient and Cronbach’s alpha was calculated to be slightly lower at 0.79.
3.2.2 Conceptual Understanding: Force Concept Inventory
To investigate the participants’ conceptual understanding in physics, we adopted the Force Concept Inventory (FCI) developed by Hestenes et al. (1992). The FCI was designed to assess students’ understanding of the most basic concepts in Newtonian physics using everyday language and common-sense distractors. It consists of 30 multiple-choice questions. Since being developed, the FCI has been used hundreds of thousands times by several hundred institutions worldwide. The reliability coefficients measured by Kuder-Richardson formula 20 from these studies have been reported between 0.86 to 0.89 (Lasry et al., 2011). As such, the FCI is considered to be a highly reliable and effective instrument to assess students’ conceptual understanding about basic physics concepts.

| Scale          | Dimension       | Content                                                                 | Meaning                                                                 | Item |
|----------------|-----------------|------------------------------------------------------------------------|------------------------------------------------------------------------|------|
| Cognitive      | Knowledge       | Beliefs about the structure and content of physics knowledge           | Whether it means a single coherent system or a collection of isolated pieces | 2, 6, 8, 9, 13, 14, 17 |
|                | Learning        | Beliefs about learning physics or activities and work necessary to make sense out of physics | Whether it involves an active process of reconstructing one’s own understanding or receiving information | 1, 4, 7, 10, 11, 18, 19, 21 |
|                | Relation        | Beliefs about relationship between physics and everyday life          | Whether physics is useful in thinking about experiences outside the classroom or it is unrelated to them | 3, 5, 12, 15, 16, 20 |
| Motivational   | Expectation     | Beliefs about one’s ability of performance in physics tasks           | Whether one has self-efficacy in learning physics or not                | 22, 25, 27, 29, 31, 33, 35 |
|                | Value           | Beliefs about the aim and value of learning physics                   | Whether one evaluates physics and learning as valuable or not           | 23, 24, 26, 28, 30, 32, 34, 36 |
The FCI focuses on basic concepts such as kinematics, force, laws of motion, and gravity, which provide fundamental bases for other areas in physics including thermodynamics, electromagnetism, modern physics, and mechanics. Although the FCI measures students’ understanding in mechanics, it can also be utilized to assess student’s conceptual understanding of general physics concepts because understanding about mechanics can influence students’ understanding about other physics concepts (Galili, 1995). Many studies on students’ misconceptions in physics have focused on mechanics (e.g., Clement, 1982). For this reason, researchers (Lewis et al., 2021) have reasoned that this tool can serve as an effective summative assessment of students’ conceptual knowledge at the end of an introductory physics course. A recent study (Stoen et al., 2020) suggested that performance on the FCI may reflect a number of student attributes, including relational knowledge structures of physics concepts, expert-like attitudes, and problem-solving skills. The FCI has been widely used to assess students’ conceptual understanding in physics and to evaluate the effectiveness of instruction in general (Hestenes & Holloun, 1995; Savinainen & Scott, 2002; Eaton, Vavruska, & Willough, 2019). The FCI has been used mainly with university students, which has resulted in a greater recognition of the value of this tool in the physics education research community. For these reasons, we assumed students’ FCI scores could represent students’ overall understanding of the physics concepts taught in the general physics course for 2nd-year students.

### 3.2.3 Achievement (Grades) in Physics Courses

To investigate the participants’ achievement in physics, we utilized students’ final grade for the 1-year general physics course (Advance Physics I & II). The final grade was derived from the total sum of all test and quiz scores for the year. As the same professor did not teach both semester courses, the tests and quizzes were not exactly the same – but the tests and quizzes were developed using typical physics exercises and end-of-chapter problems in the physics textbook used by all students in the courses. For this reason, it can be assumed that there was some consistency of assessment of topics across the different sections of the course. The final grade score was derived from the total sum of all quizzes and tests and represents students’ achievement for problem solving in different areas of physics covered during the whole year.

### 3.3 Data Collection

Participants’ beliefs about learning physics were measured twice, once at the start of the first semester of their 2nd-year program, and again at the end of the second semester of the academic year. Participants completed the FCI at the end...
of second semester, and the final grade scores in both physics courses were collected at the end of the academic year. All data was collected over one academic year in 2015 (in Korea the academic year runs from March to December).

3.4 Data Analysis
We performed descriptive statistics on participants’ responses for all survey data collected. The descriptive statistics include the mean and standard deviation (SD) for each variable. For beliefs about learning physics, we calculated the mean and SD of pre- and post-tests relative to the five dimensions of the scale, which were Knowledge, Learning, Relevance, Expectation, and Value. The participants’ responses for the FCI were calculated as ratios of correct answers (RCA) for the 30 questions in the inventory. The RCA was utilized to represent the results of the FCI since the original research suggested this was a useful way to interpret responses (Hestenes et al., 1992). For the participants’ grade scores in the two physics courses, we converted the letter grades to a 100-point scale and we described the mean and SD of the points according to grade score.

To explore the statistically significant differences, we conducted data normality tests to decide whether to do parametric or non-parametric analysis. The Shapiro-Wilk test indicated that the differences of beliefs in four of the five dimensions of the beliefs data set satisfied the normality tests (p > 0.01) but the Value dimension did not (p < 0.01). The other variables including pre- and post-tests of beliefs, FCI scores, and grade scores satisfied the normality test with a significance level of p > 0.01.

We conducted a correlation analysis to investigate possible relationships between beliefs about learning physics and learning achievement in physics. We also checked the correlation between the FCI responses and students’ grade scores. As both the FCI responses and grade scores satisfied a normal distribution (Table 2), we utilized Pearson coefficients to check correlation between variables. For statistical analysis, we used the IBM Statistical Package for Social Sciences (SPSS) version 25.

| Scale                      | Statistics | Df | Sig.  |
|----------------------------|------------|----|-------|
| Beliefs about learning physics (pre-test) | Knowledge | .873 | 14 | .051 |
|                            | Learning   | .909 | 14 | .152 |
|                            | Relation   | .949 | 14 | .550 |
|                            | Expectation| .930 | 14 | .304 |
|                            | Value      | .938 | 14 | .393 |
Results and Discussion

4.1 Description of Pre-service Physics Teachers’ Beliefs about Learning Physics and Learning Achievement

4.1.1 Beliefs about Learning Physics and Their Change during a One-Year Physics Courses

The overall distribution of pre-service physics teachers’ beliefs about learning physics is shown in Table 2. The BAPS is a 4-points Likert-style questionnaire to assess the level of agreement or disagreement on belief statements that most physics experts regard as favorable. Larger numbers represent a stronger agreement with experts’ beliefs, so student responses that are greater than the median value (2.5) can be interpreted as sharing expert-like beliefs about physics. Responses of less than 2.5 can be interpreted as not sharing expert-like beliefs.

Based on pre-service physics teachers’ pre-test responses at the beginning the physics course, teachers showed relatively high scores on several dimensions. Responses to dimensions representing the cognitive belief scale showed relatively high scores for the Relation (3.08), Learning (2.66), and Knowledge (2.61) dimensions. Responses to the dimensions representing the motivational belief scales showed students held relatively high beliefs about the Value (3.23)
dimension, but the Expectation dimension had the lowest overall score (2.37) of all dimensions.

The overall score for beliefs about learning physics on the pre-test was 2.79. This showed that the participants held slightly positive beliefs. The participants believed that physics was related to everyday life and that learning physics was a valuable thing. Post-test scores at the end of the physics courses showed that the distribution of beliefs was very similar to the pre-test results. The only changes were that the Learning dimension had decreased slightly, and the other dimensions had increased very slightly.

To check the statistical significance for these differences, we conducted the paired $t$-test for pre- and post-test. The result of $t$-test showed that these changes were not significant. However, as the sample size in this study ($N = 14$) was so small, it is difficult to meet the assumptions of the parametric test. For this reason, we had to utilize a non-parametric test to validate the result of $t$-test. Unlike the $t$-test, the Wilcoxon signed-rank test, which is a non-parametric statistical hypothesis test used to compare the locations of two populations using a set of matched samples, does not assume that the data is normally distributed. Therefore, we utilized the Wilcoxon signed-rank test to complement the $t$-test. The results of the Wilcoxon test shows that the median of differences between pre- and post-test in all dimensions equals zero (Table 3). This conclusion was expected as there was no significant difference between the pre- and post-test. As a result, we can infer that pre-service physics teachers’ beliefs about learning physics may be a stable construct that resists change regardless of learning.

| Scale       | Dimension  | Pre (mean ± SD) | Post (mean ± SD) | Z   | p   |
|-------------|------------|-----------------|------------------|-----|-----|
| Cognitive   | Knowledge  | 2.61 ± .35      | 2.66 ± .32       | .89 | .37 |
|             | Learning   | 2.66 ± .42      | 2.61 ± .32       | −.83| .40 |
|             | Relation   | 3.08 ± .28      | 3.15 ± .41       | .85 | .39 |
| Motivational| Expectation| 2.37 ± .43      | 2.40 ± .47       | .22 | .82 |
|             | Value      | 3.23 ± .24      | 3.24 ± .54       | .87 | .39 |
| Total       |            | 2.79 ± .24      | 2.81 ± .33       | 1.60| .29 |

($N = 14$)
4.1.2 Learning Achievement: Conceptual Understanding and Grade Scores in Physics

The distribution of pre-service physics teachers’ learning achievement is shown in Table 4. Learning achievement is represented as the FCI score, which represents conceptual understanding, and students’ final grade scores at the end of the two semesters of physics courses. All scores were converted into percentile points. The mean value of the FCI score was 77.9%, which is relatively high in consideration that the values measured at the end of physics learning in previous research have varied from 48–77% (Hestenes et al., 1992). The mean value of the grade score was 52.3%, which is lower than the FCI score. Standard deviations of two scores were similar, so we can assume the distribution pattern of participants’ learning achievement was similarly irrelevant to the type of test. The correlation coefficient between the FCI and grade score was 0.672 \( (p = 0.008) \). This implies that participants’ conceptual understanding and grade scores in both physics courses were significantly related to each other.

While there were no significant differences between pre- and post-test beliefs scores, we questioned whether there were any differences in their correlations with conceptual understanding and grade scores in physics. To find which aspects of beliefs had a more significant relationship with learning achievement, including conceptual understanding or grade scores, we conducted a correlation analysis between beliefs and learning achievement. The results are shared below.

|                | Mean | SD  | Correlation |
|----------------|------|-----|-------------|
| FCI            | 77.9 | 17.0| .672**      |
| Grade          | 52.3 | 16.1|             |

\( (N = 14, **p < .01) \)

4.2 Correlation between Pre-service Physics Teachers’ Beliefs about Learning Physics and Learning Achievement

4.2.1 Correlation between Belief about Learning Physics and Conceptual Understanding

To see possible effects of pre-service physics teachers’ beliefs about learning physics upon their conceptual understanding, we investigated the correlation between their beliefs about learning physics and their conceptual understanding of physics (Table 5). Beliefs about learning physics were measured both at
Table 5  Correlation analysis of beliefs about learning physics and conceptual understanding

| Scale               | Dimension | Conceptual understanding |
|---------------------|-----------|--------------------------|
| Cognitive beliefs   | Knowledge | Pre .592*                |
|                     |           | Post .596*               |
|                     | Learning  | Pre .669**               |
|                     |           | Post .552*               |
|                     | Relation  | Pre .566*                |
|                     |           | Post .595*               |
| Motivational beliefs| Expectation| Pre .291                |
|                     |           | Post .489                |
|                     | Value     | Pre −.126                |
|                     |           | Post .346                |

(N = 14, **p < .01, *p < .05)

The beginning and the end of the one-year physics course, and the conceptual understanding of physics was measured only at the end of the course.

The results show that three dimensions of cognitive beliefs on both the pre- and post-tests had significant correlation with students' conceptual understanding of physics, while two dimensions of motivational belief did not have significant correlation. The learning dimension at the beginning of the course in particular had the highest correlation with conceptual understanding.

From this result we can infer that cognitive or epistemological beliefs held by students when learning physics are related to their conceptual understandings. This result confirms previous studies which showed positive correlation between beliefs about physics knowledge and physics learning, such as conceptual understandings (Hammer, 1994b; Tsai, 1998, 1999; Im, 2001). We can conclude that cognitive beliefs have an important role in learning physics, but we cannot tell whether they are the cause or effect in the learning process. Despite this, we can recognize that it is important for physics teachers to consider students' cognitive beliefs about physics as a potential resource for students' learning (Elby, 2001; Im, 2008).

It is interesting that motivational beliefs were not related to conceptual understanding in learning physics, even though motivation has long been considered an important factor to affect learning.
4.2.2 Correlation between Belief about Learning Physics and Grade Score in Physics

To see the possible effect of pre-service physics teachers’ beliefs upon their learning physics in different ways, we investigated the correlation between their beliefs about learning physics and grade scores in physics at the end of a 1-year physics course (Table 6).

In this case, only the learning dimension of cognitive beliefs in both the pre- and post-test had high correlation with the course grade scores. On the other hand, all dimensions of motivational beliefs had significantly positive correlations with course grade scores. If we look more closely at the results, we see that participants’ motivational beliefs correlated only with the post-test results, but the pre-test results showed no significant correlation. This result is interesting in that there was no significant difference between pre- and post-test scores for participants’ beliefs about learning physics. This implies that motivational beliefs might have an effect on learning, but may not be the cause of achievement in learning physics.

While previous studies about beliefs in learning contexts have focused on the conceptual or qualitative aspect of learning, relatively few studies, with the exception of Schommer’s (1990, 1993, 1994) have studied how beliefs can be related to measures of students’ general achievements in physics, such as students’ grade scores. In this study, we found that epistemological beliefs about

| Table 6 | Correlation of beliefs about learning physics and grade score in physics |
|---------|-----------------------------|
| **Scale** | **Dimension** | **Grade scores** |
| Cognitive belief | Knowledge | Pre .451 |
| | | Post .439 |
| | Learning | Pre .680** |
| | | Post .620** |
| | Relation | Pre .499 |
| | | Post .713 |
| Motivational belief | Expectation | Pre .181 |
| | | Post .655** |
| | Value | Pre .310 |
| | | Post .679** |

\(N = 14, **p < .01, *p < .05\)
knowledge and its usefulness had no significant correlation, but beliefs about how to learn, that is, the learning dimension of beliefs, did show a positive correlation with grade scores in physics.

5 Conclusion and Implications

In this study we investigated pre-service physics teachers’ beliefs about learning physics during a 1-year physics course and explored the correlation between beliefs and their learning achievement relative to their conceptual understandings and grade scores in physics. The results of this study can be summarized as follows:

First, pre-service physics teachers had slightly positive beliefs about learning physics, especially in relation to the dimensions of cognitive beliefs and in the Value dimension of motivational beliefs. Teachers showed slightly negative beliefs only in the Expectation dimension of motivational beliefs. This distribution of beliefs did not change even after one year of learning in general physics courses. This result implies that beliefs about learning physics are stable and resistant to change. This stability is similar to students’ pre-conceptions, which have been shown to have a great effect on learning. In other words, this result implies that understanding students’ beliefs is as important as understanding students’ pre-conceptions. This implication is supported by two recent studies, one conducted in China, which found that university students’ epistemological beliefs influenced their learning of physics (Chen et al., 2019), and the other, conducted with secondary school students in Greece, showed similar results (Stathopoulou & Vosniadou, 2007).

Second, pre-service physics teachers’ beliefs about learning physics had a positive correlation with their conceptual understanding in all dimensions of cognitive beliefs, but there was no correlation with motivational beliefs. The relationship pattern was same in both the pre- and post-test results about beliefs. We can infer that pre-service physics teachers’ cognitive beliefs can have an impact on their conceptual understandings, regardless of their learning experiences. This result supports findings from previous research, which has shown that students’ epistemology is related to their understanding, meaning that learners’ cognitive beliefs can be both a resource for learning and teaching for both students and teachers (Elby, 2001; Im, 2008).

Last, pre-service physics teachers’ beliefs about learning physics had a positive correlation with grade scores in physics, but only on the Learning
dimension of cognitive beliefs. This was true for both the pre- and post-test. The grade scores in physics were also positively correlated with all dimensions of motivational beliefs, but only at the end of the course. This result supports findings from previous research, which found motivational beliefs play a role in students’ conceptual change and academic performance (for example, Linnenbrink & Pintrich, 2002; Lynch, 2010). This result implies that motivational beliefs may not affect learning achievement, but rather be affected by successful achievement such as good grades. However, this study only suggests correlation between variables, not a causal relationship. So to definitively discuss the role of motivational beliefs, we would need more robust statistical data.

From this study we can suggest several implications about how to utilize pre-service physics teachers’ beliefs about learning physics as an epistemological resource for teaching and learning physics, especially for secondary and tertiary physics education. First, the description of students’ beliefs about learning physics can be used as information to design instructional strategies for physics education. Physics teachers can consider differentiated approaches according to students’ cognitive beliefs about learning physics, especially what they think about how to learn physics. If a majority of students believe that learning physics means just memorizing or recollecting information, physics teachers should organize their teaching to effectively show the coherence and structure of knowledge and invite students into active engagement in learning (Knight, 2004). For example using the Socratic dialogue-inducing lab (Hake, 2012) or inquiry-based experiment with small-group discussion (Im, 2008). Second, students’ beliefs about learning physics may serve a predictor of students’ achievement in physics, especially in relation to conceptual understanding. A student who believes that learning physics includes an active process of reconstructing one’s own understandings, not just receiving information, has a greater chance to succeed in learning physics. A physics teacher can encourage students who do not have such beliefs to be more actively involved in the learning process. This could include using a meta-cognitive strategy in that what students bring to the classroom would play an important role in their learning of physics. Physics teachers can work to activate students’ meta-cognitive abilities while learning physics to support their successful learning. This implication can be applied to both secondary and tertiary level of physics education. This is well supported by previous research that has shown high correlation between meta-cognitive skills and student achievement in physics for 15-year-old students (Bogdanovic et al., 2015).
On the other hand, beliefs about learning physics can be an indicator of successful physics learning including conceptual understanding and achievement in coursework. In other words, fostering favorable beliefs about learning physics can be suggested as an aim of learning physics. The aims of physics education cannot be confined only to having students understand physics content knowledge but should also be extended to having a broader awareness of physics. To be aware that physics knowledge is not just knowing a formula or having memorized some facts, but that knowledge also includes having an understanding of a coherent framework about physics and how it can be related to students’ lives and the world around them, is as worthwhile as understanding physics knowledge. This goal may be more attainable in the context of informal science education, where the goals of science communication have been shifting from public understanding of science to public awareness of science (Stocklmeyer et al., 2001).

This study was done with a small number of participants using mostly quantitative analytical methods. The small sample size is a limitation as it does not allow for robust statistical analysis. As a result, we can only provide descriptive statistical analysis to report on general trends. In spite of such limitations, the results suggest that the beliefs students bring into the physics classroom can have an impact on their learning achievement. Belief itself seems not to affect the learning process directly, but it may induce other kinds of cognitive processes or activities that directly impact learning. One possible idea is that beliefs may affect one’s meta-cognitive strategies, such as reflecting on one’s learning, and this can evolve into even more active learning practices that could help students to link new ideas with their previous conceptual framework. Additional qualitative and quantitative research is needed to examine why and how beliefs play a role in learning physics.

Abbreviations

BAPS   Beliefs About Learning Physics Survey
FCI   Force Concept Inventory

Ethical Consideration

Approval to conduct this study was granted by the Daegu University Institutional Review Board. The data collected from this project were obtained with the necessary permissions of the students involved in the study.
About the Authors

Hong-Jeong Kim is a curator at the Exhibition Division, National Science Museum, Republic of Korea. His research focuses on education using science exhibitions and collections, activities of science centers, and museums in informal science education.

Sungmin Im is a professor in Physics Education at Daegu University, South Korea. His main interests are using qualitative research and sociocultural theories to improve physics teacher education. He has worked as a PI in many governmental studies on STEAM education and educational policy for minorities.

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