

Exploring the Connections between Epistemological Beliefs, Worldviews, and Psychological Self-Efficacy of Preservice Science Teachers

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Abstract

The study investigates the epistemological beliefs of elementary school preservice science teachers (PSTs) and the connections between those beliefs, their epistemological worldviews, and their sense of professional competence. The Science Teaching Efficacy Belief Instrument, the Epistemological World Views Scale, and the Epistemological Questionnaire were completed by 429 PSTs from five major institutions in Asia. Factor analysis revealed four elements of the Epistemological Questionnaire: All-Knowing Power, Simple Knowledge, Certain Knowledge, and Innate Capability. Multiple regression analysis showed that self-efficacy, result expectation, and worldview were significant predictors of "Innate Ability" component scores. Epistemological worldviews were found to be a significant predictor of "Simple Knowledge" scores, while only result expectation significantly predicted "Certain Knowledge" scores. The scores on the "Omniscient Authority" item did not differ substantially based on any of the predictor factors. The findings suggest that PSTs in Asian culture hold multidimensional epistemological beliefs, and while they may have acquired more nuanced views on some aspects, their beliefs on others were less nuanced. Moreover, PSTs believed that recalling scientific ideas and information is essential for students' success when using student-centered approaches to teaching science. The study provides insights into the relationships between epistemological beliefs, worldviews, and self-efficacy in PSTs. It highlights the importance of understanding how PSTs' beliefs and views can impact their teaching practices and students' learning outcomes. The findings suggest that teacher education programs should focus on developing PSTs' epistemological beliefs and worldviews, as well as their self-efficacy, to promote effective science teaching practices.

Keywords: *Self-Confidence, Epistemological Worldviews, Science Teaching, Preservice Educators*

Introduction

Theories of Knowledge (or Epistemology)

Epistemology refers to the study of "the beginnings, boundaries, means, and justifications of human knowledge" (Barger et al., 2018). A person's epistemological belief is a firm conviction about how knowledge works (Tawfik et al., 2018). Someone's epistemology is formed by the confluence of their many, often conflicting, views about how knowledge is acquired and interpreted. Various scholars have come up with different ways to categorize individuals' epistemic convictions (Celik et al., 2021). Five distinct points of view were found by researchers (Celik et al., 2021). These were omniscience, speedy learning, innate talent, simple but sure knowledge, and innate authority. There is likely to be a diversity of opinion across all dimensions. To provide just one example, a science teacher's view of Certain Knowledge might lay anywhere along the spectrum from the view that science is static to the view that it is dynamic. The study of how knowledge works is called epistemology. Since then, two definitions of individual epistemologies have emerged. Individual epistemologies have been considered by some scholars as a progression through life. According to this understanding, individuals' epistemologies evolve in tandem with their growing capacity for knowledge. For instance, they suggested a seven-stage model for the development of individual worldviews. At the earliest age, a kid will accept the authority of adults as the ultimate source of information. In the last level, knowledge is understood to be constructed from accumulated observations but is still open to individual evaluation. Personal epistemologies are seen as unidimensional structures by researchers who subscribe to this development scheme because they believe that people's epistemologies follow a linear progression parallel to their cognitive maturation. It is unusual for someone to hand down a higher level of epistemological knowledge without having attained a lower one before. Personal epistemologies were characterized as sets of assumptions by a different set of academics. Epistemological views are held on the character of knowledge (Celik et al., 2021). It was stated that people are capable of forming epistemological ideas on the reliability of information, its justification, its acquisition, and its organizational structure. Because of this, scholars have adopted a multidimensional definition of epistemological beliefs. That individual epistemologies are intricate, multidimensional cognitive developments is a given in unidimensional theory. The ways in which individuals form or acquire epistemic ideas or beliefs are one area in which unidimensional and multidimensional theories diverge. According to the unidimensional theory of knowledge, distinct stages of intellectual growth result in different levels of epistemological comprehension. That is to say, if a person advances through the lower levels of epistemic development, she will inevitably advance through the higher levels as well. On the other hand, multidimensional theory posits that if one develops one dimension of epistemological ideas, one may or may not go on to develop additional dimensions (s). Methods from both quantitative and qualitative research were used to investigate students' epistemic perspectives. Quantitative evaluation of epistemic views on several dimensions was first attempted in (Celik et al., 2021). The epistemological questionnaire she created was shown to be valid by her research (Celik et al., 2021). There are five postulated epistemological assumptions in the questionnaire employed by (Celik et al., 2021). These hypotheses are: (a) the continuity of belief from certain knowledge (simple, less developed belief) to tentative knowledge (developed, more complex belief) — Certain Knowledge; (b) the structure of knowledge ranging from isolated bits and pieces (simple, less sophisticated belief) to integrated concepts (developed, sophisticated belief) — Simple Knowledge; (c) the source of knowledge ranging from omniscient authority to reason (simple, less sophisticated belief) and empirical evidence (developed, sophisticated belief) — Omniscient Authority; (d) the speed of learning ranging from quick (simple, less sophisticated belief) or not-at-all to grasp (developed (developed and sophisticated belief) Natural Talent. Multiple investigations were conducted (Celik et al., 2021) to ensure the validity of the questionnaire. Although four common elements emerged throughout these investigations, their labels varied widely based on factors such as sample size, demographics, and the specifics of the studies themselves. One study (Celik et al., 2021) saw her working with a total of 148 college freshmen and 118 sophomores at a junior college. In this sample of students, four variables emerged from the factor analysis. The first factor, "Ability to learn is inherent," was followed by "Knowledge is distinct and unambiguous," "Learning is swift or not at all," and "Knowledge is certain" (Certain knowledge). (Celik et al., 2021) conducted research with 425 college and university level learners. For the purpose of gauging students' epistemological convictions, the original

questionnaire was re-established. There were a total of three new variables this time. Learning is rapid and natural" was the first contributing factor (Innate Ability). Sub-factor 2 stated that "information is distinct and clear" (Simple Knowledge). Knowledge is both definite and debatable, which brings us to our third consideration (Certain Knowledge).

Knowledge and Belief Systems

The collective ideas and assumptions that educators have about what constitutes knowledge and how it is acquired constitute their epistemological world views (Tawfik et al., 2018). Tawfik et al. (2018) classified these common convictions into the realist, contextualist, and relativist camps according to their underlying assumptions. Each grouping included not just a set of epistemological views, but also additional beliefs, such as those about the origins, growth, and evolution of one's epistemological beliefs. Teachers who have a realist worldview consider themselves as actors in the classroom since they are responsible for the transmission of information to their pupils, who are seen as receptive receivers of that knowledge. Conceptualist educators place an emphasis on their students' active participation in the learning process and the integration of new concepts into their existing worldviews. Teachers that have a relativist perspective encourage student autonomy in the classroom.

Epistemological world views and epistemological beliefs vary in important ways. Beliefs with the hallmarks of knowledge, such as certainty, simplicity, or a credible source, are categorized as epistemological. An individual's perspective on knowledge and how it is gained is shaped by their epistemological world view. Although "world perspective" has been used in other research, we felt it better reflected the focus of our investigation (Tawfik et al., 2018). The phrase "epistemological world view" was used for two main reasons. As one author put it, "a world view suggests a broad intellectual perspective that serves as a lens to see the world that transcends individual beliefs about knowledge," and as another wrote, "it is easier from a practical perspective to communicate with teachers and students what we mean by a world view as opposed to a stance or way of knowing" (Tawfik et al., 2018).

Based on our evaluation of the available research, we found that very few studies have been undertaken to evaluate the epistemological perspectives of both current and future educators. Nonetheless, it's feasible that the epistemological world views of educators have an impact on their pupils' development. It was hypothesized by (Tawfik et al., 2018) that educators who have a relativist epistemological world view will structure their classrooms around constructivist and inquiry-based activities. Clearly, a setting like this may help kids acquire new ideas more efficiently. However, (Tawfik et al., 2018) discovered that there was little connection between epistemic worldviews and pedagogical methods. Teachers, for instance, still utilize district-mandated curriculum and expository teaching strategies despite their professed belief in the efficacy of student-centered approaches (fostering a relativist world view). In order for teachers to implement necessary pedagogical techniques that are consistent with their own epistemic worldviews, scientific educators must assist them in doing so. Preservice science teachers (PSTs) need direction from their professors throughout their studies to become qualified educators. It is necessary to establish such convictions first.

Beliefs in Self-Efficacy

The instructors' perceptions of their own effectiveness have been extensively studied. The term "teacher efficacy beliefs" was used by (Hajovsky et al., 2020) to describe educators' convictions that they have the power to influence their students' academic success and enthusiasm. Another set of researchers came up with the definition of teacher effectiveness as instructors' confidence in their ability to improve their pupils' academic outcomes. Believes in the value of learning from teachers who are effective. An individual's confidence in his or her own skills to complete a job is formed via a mental process known as self-efficacy. In this way, people's actions are affected by their perceptions of their own abilities. These actions include how hard individuals try to complete projects, how long they keep at it despite setbacks, how well they bounce back after repeated failures, and how well they cope with high levels of stress. Considering that these actions take place in a school setting, instructors' perceptions of their own abilities to teach effectively are crucial.

They argued that "people not only anticipate specific activities to yield desirable results (outcome expectation), but they also believe in their own competence to undertake the behaviors (self-efficacy)," meaning that one needs both to successfully carry out the desired activity (Thomson et al., 2019). A science teacher, for instance, may choose to use inquiry-based instruction with his or her students. When we talk about an educator's self-efficacy, we're referring to her confidence in her ability to use the inquiry method with her students. The teacher's result expectation beliefs are those concerning her pupils' potential to acquire inquiry skills (including observation, research, and the formation of hypotheses). According to (Bardach & Klassen, 2020), these attitudes are crucial for educators to feel good about their own talents as educators and to foster productive student learning outcomes. Numerous studies have shown that instructors' perceptions of their own ability to teach effectively impact their students' academic achievement and the development of emotional as well as intellectual competencies.

Several researchers have written on instructors' sense of competence in various contexts. (Şen, 2022) The Science Teachers Efficacy Beliefs Instrument (STEBI) was created by and has been widely used by researchers in science education over the last decade to measure teachers' levels of confidence in their ability to teach science (Thomson et al., 2019). The authors created the STEBI tool first for already-employed educators (STEBI-A). The device was later renamed STEBI-B and used with future science educators. The theoretical foundation of the STEBI instruments, including the reasons and methods behind item creation, is a major selling point (Thomson et al., 2019). Two dimensions were developed (Thomson et al., 2019) to measure people's confidence in themselves and their ability to achieve their goals. They employed aspects of social cognition theory related to self-efficacy and outcome anticipation to make their classifications. These measures treat instructors' confidence in their own abilities and their expectations for student achievement as two separate entities. Therefore, some educators may have faith that their teaching methods lead to student achievement gains, but they may lack the abilities to really affect their students' education. Numerous empirical investigations have examined this instrument and come to the same conclusion: it has two separate dimensions, self-efficacy and result expectation. We hypothesize that PSTs' and students' epistemological views have an effect on both teachers' and students' perceptions of teaching effectiveness and students' expectations of learning outcomes. As an example, we believe that teachers who have less nuanced views on Certain Knowledge are more likely to feel confident in their ability to convey scientific concepts as immutable truths to their students (Certain Knowledge). As a result, the purpose of this research was to investigate the nature and extent of the connections between epistemological and self-efficacy beliefs.

Cause and Reason for the Study

There are two main goals to this research. It is, first of all, connected to traits, and secondly, it takes into account the interplay between the variables under investigation. Our study of the epistemological, self-efficacy, and worldviews of aspiring primary school science teachers sprang from a number of concerns. In the first place, it has been claimed by (Celik et al., 2021) that one's epistemological ideas are shaped by one's upbringing and environment. It is crucial to study the epistemological views of Asian preservice teachers since there is a dearth of research on the topic. This is especially true when considering the role that the Asian educational system and culture have had in the formation of these ideas. The results of this research might be utilized to back up current initiatives to improve science and technology education. secondly, it has some distinct and intriguing qualities. has historically been shaped by both East and West, and information gathered from the Asian setting in terms of epistemology may provide light on how the two schools of thought vary. Last but not least, is in the process of revising parts of its educational policy that affect classroom instructors and pupils. As a result, the results of this research may greatly aid in directing such initiatives on a regional and national scale.

We speculate that there is a link between educators' epistemological beliefs, epistemological world views, and beliefs in their own abilities to teach. Teachers' views on the epistemology, or the study of knowledge, are known as epistemological beliefs (Simple Knowledge, Certain Knowledge, Innate Ability, Omniscient Authority, Quick Learning). It's possible that a teacher's epistemic worldview is shaped by their own preconceived notions about the nature of knowing (relativist, realist, conceptualist). We may anticipate a teacher

to have a realist world view, in which they pass on the scientific information acquired by scientists to their pupils, if that teacher has a less nuanced belief about Omniscient Authority, in which the teacher thinks that scientific knowledge is possessed by authority. Because of the correlation between teachers' epistemological worldviews and their pedagogical approaches, this educator's sense of professional competence may be affected by the epistemological worldview they hold. However, one must use caution when examining the relationships between these concepts, since they might develop in any way. The path described above, for instance, is epistemological beliefs > epistemological world views > self-efficacy beliefs. This correlation, however, is not limited to any one of these variables and may appear in varying degrees under a variety of circumstances. It was the goal of this research to assess the nature and strength of the connections between these variables.

The purpose of this research was to identify the epistemic worldviews held by PSTs and to investigate the connections between those worldviews, beliefs, and sense of competence. This study aimed to answer the following questions: (1) What kinds of epistemological beliefs do PSTs hold? and (2) What are the connections between epistemological views, epistemological world views, and self-efficacy beliefs?

Method

Sample

Four hundred and twenty-eight PSTs from five research institutions in three major metropolitan areas filled out the Epistemological Questionnaire (EQ). There were 428 people total, with 244 females and 184 males. This method of collecting information allowed us to record the varied perspectives of PSTs from various educational institutions. Because we wanted to get a big picture picture, we didn't include geographic location as an independent variable in this research. Three major research institutions in this city provided the data used to create a profile of the city's college students. A total of 325 aspiring educators from these three schools took part. Since each of the other two cities has more than one research university, students from just one institution in each of those locations were included in the sample. Twenty-five secondary education majors and seventy-five elementary education majors took part in the research. These schools were all public universities. All of the students in the study agreed to take part in it on their own free will.

Instruments

The EQ was created by (Celik et al., 2021) to gauge the epistemic stances of university students. There are sixty-four questions total in the survey. Student responses are one of five possible choices for each question (strongly disagree, disagree, undecided, agree, and strongly agree). For each statement, we assigned a score between -1 and +5. Someone who scored higher on the poll is assumed to have less complex knowledge because of this. This survey is broken up into 12 different sections. The amount of elements varies from one subset to the next. Previous validation of the Asian translation of the EQ was performed. Two academics of Asian ancestry translated the EQ into the language. After the Asian translation was complete, a multilingual assistant professor specializing in epistemological problems and the nature of science and now pursuing his research in Asia reviewed both the original and translated surveys. After going through this procedure, everyone was on the same page. As soon as the translation was complete, a pilot research was conducted with 94 future science instructors. We used a factor analysis to ensure the reliability and validity of the scale. Similarly, to the research, we were able to accurately portray the epistemological convictions held by PSTs in an Asian setting. Each factor's item dependability was determined. We chose to maintain everything for the research since it everything functioned as intended. The hypothetical dimensions used to categorize the 12 subgroups shown in Table 1 are briefly discussed below. categorize these 12 groups into the best possible hypothetical dimensions. During the study, her primary goal was to determine how well each of these 12 subgroups loaded into their respective fictitious dimensions.

Table 1. Sub-samples of the epistemological survey's hypothetical dimensions

Subset dimension	Hypothetical dimension
Simple Knowledge	Find the one true explanation Don't try to integrate
Certain Knowledge	Be clear and concise. The certainty of knowledge
Omniscient Authority	You should never criticize those in positions of power. Trust in the higher-ups Not capable of learning new material
Innate Ability	Success has nothing to do with effort. An inborn capacity for learning Rapid education
Quick Learning	Understand the basics first No amount of focused work is worth your time.

Inter-item dependability for the components making up each element of the EQ ranged from .51 to .78, providing a measure of its consistency (Celik et al., 2021). They conducted several investigations, all of which are briefly discussed in the introduction, to verify the EQ. She used factor analysis in her investigations and discovered that there were often three or four underlying components. Specifically, they were Natural Talent, Basic Information, Rapid Acquiring, and Solid Information. Since the subsets did not load into this fictitious dimension, she was unable to identify Omniscient Authority as a single component in any of her research.

Measuring How You Think the World Works with Your Current View of Epistemology. The three major approaches to knowledge are represented on this scale. These are categorized as realist, conceptualist, and relativist (Tawfik et al., 2018). All of these worldviews were broken down into the following categories: It is ideal to learn from professionals via the processes of transmission and reconstruction, according to realists. "Conceptualists think that learners create common understandings in supportive situations where instructors function as facilitators." According to relativists, "each student creates a unique knowledge base that is distinct yet equal to the knowledge of other learners." With a realist worldview, educators focus on imparting information to their pupils rather than engaging with them as individuals. These educators use standardized examinations or other norm-referenced instruments to evaluate their pupils' progress. Their goals are to assess how much students have learned from a particular unit and to compare the learning of different pupils. If educators adopt a contextualist worldview, they will prioritize the way in which students learn rather than the content of that learning. Teachers recognize their central position in this process and actively promote student-to-student and student-to-expert help and scaffolding. If educators adopt a relativist worldview, they foster a classroom setting in which students' unique ways of knowing are valued and respected. As a result, most classrooms nowadays have an emphasis on student-led instruction. Teachers facilitate students' self-regulation in this way so that they may acquire information independently down the road. Teachers employ criterion-based evaluation tools to evaluate their students' progress in class. Because of their prevalence, the words realist, conceptualist, and relativist were used for this analysis. There are three short stories included inside this tool. A five-option, three-item Likert scale was employed for each scenario. Epistemological World View Scale translation validity was established using an approach similar to that used for the EQ. A measure of one's own sense of competence. Study participants filled out the STEBI-B (preservice version) created by (Thomson et al., 2019). Personal Science Teaching Efficacy Belief Scale (self-efficacy dimension) and Science Teaching Outcome Expectancy Scale (outcomes dimension) were the two measures included in the STEBI-B. (outcome expectancy dimension) One may choose from five options on the STEBI-B. For this survey, we used a 23-item Likert scale with five possible responses. Thirteen questions were used to measure self-efficacy, whereas ten questions were used to measure result anticipation. The questions on both the self-efficacy and result expectation scales were shown to have strong reliabilities (Thomson et al., 2019). (.89 and .76, respectively).

Data Collection and Analysis

The 2018 autumn semester was used for data collecting. Each campus has an assistant who handled the weighing. All data collecting locations had a response rate of 80% or above. Each aide was briefed on how to administer the scale in order to guarantee uniformity in the collecting of data. Helpers distributed flyers and discussed the study's goals to students in class, after which they were given the option to freely participate. Students who consented to take part in the study filled out the questionnaire in class with the help of TAs, who were on hand to field any questions from the students. The completed questionnaires were gathered by the researchers and sent back to the authors.

To begin understanding the EQ's component structure in an Asian setting, factor analysis was performed on the collected data. With this breakdown, we were able to evaluate our findings against those of prior studies. After factor structure was established, factor scores were computed using factor analysis. These factor scores were used for further investigation.

As a second step, multiple regression analysis was performed to investigate any relationships between the predictor variables and EQ factor scores. The most accurate statistical model for the EQ's individual factor scores was determined using a stepwise regression analysis. According to the statistical standards, predictor variables were included in the model in this investigation. When investigating a dataset like the one presented in this paper, a stepwise strategy is employed in which a regression analysis is begun with no variable, and each predictor variable is added to the equation, one by one, to determine whether the predictor variable significantly contributes to the regression equation (Busico et al., 2020). Statistical Package for the Social Sciences (SPSS) for Windows was utilized for all of our studies.

Results

Analysis of the EQ's Factor Structure

Using factor analysis, we were able to identify the number of variables and their properties that may explain the students' replies to the questionnaire. As part of this investigation, the aforementioned subgroup scores were calculated. When calculating the 12 subset scores, we used the average of the subset item scores. In factor analysis, the 12 groups of items served as independent variables.

Four factors, explaining 54.61 percent of the variation, were extracted using "primary factoring extraction," which included orthogonal varimax rotation and a cutoff eigenvalue of more than one. In the data, four factor structures were found using factor analysis. As a result of the methodology she used in her research, certain elements were identified. On the basis of the subgroups of items with the highest loadings, she titled each component descriptively. She limited herself to the subgroups with factor loadings greater than .50 while naming the factors. Similar logic was used to the titling of our factors. The first factor we identified, "Innate Ability," combines the dimensions "Cannot learn how to learn" and "Success is unrelated to hard effort." The second factor, "Certain Knowledge," contains the "Avoid ambiguity" subfactor. The third factor is "Simple Knowledge," and under it, the "Seek single answers" dimension is included. The subset dimension "Depend on authority" is a part of Factor 4, which is called "Omniscient Authority."

Table 2 displays the correlation between factor variance and eigenvalues.

We also tried oblique rotations to identify better factor structures, but we couldn't get more meaningful results than we did with orthogonal varimax rotation. We found similar evidence in our factor analysis results, which showed that the epistemological views that preservice teachers form are a collection of distinct ideas rather than a single component.

In her research, she discovered that the inter-item reliabilities for the items that make up each component ranged from .20 to .60. Dimensions (such as "Knowledge is certain") could not load into their predicted dimension for some of the subsets, as shown in Table 2. However, this subset's dimensions loaded strongly to additional variables. This result demonstrated that it is possible that Asian participants failed to

properly discriminate subgroup items owing to their similar meaning. It's possible that participants' inability to tell the items apart affected their dependability ratings being lower than expected in this research.

Table 2. Principal Components Analysis Factor Loadings

Subset	Factor Loading			
	1	2	3	4
1. Cannot learn how to learn	.727	-.110	.040	.011
2. Concentrated effort is waste of time	.671	-.001	.004	.237
3. Avoid integration	.657	.120	.225	.046
4. Success is unrelated to hard work	.620	.202	-.180	-.133
5. Do not criticize authority	.613	.033	.099	-.066
6. Learning is quick	.568	.144	-.094	-.115
7. Learn the first time	.478	-.033	-.118	.163
8. Avoid ambiguity	-.102	.768	.211	.195
9. Ability to learn is innate	.294	.759	-.066	-.180
10. Knowledge is certain	.295	-.029	.781a	-.075
11. Seek single answers	-.321	.192	.646	.037
12. Depend on authority	.067	.026	-.032	.925
Eigenvalue	3.059	1.413	1.056	1.024
% of variances	25.494	11.774	8.804	8.535

Discordant loadings pattern with the expected epistemological dimensions.

Examining the Ties That Bind: How PSTs' World Views, Efficacy Beliefs, and Semantic Knowledge

Each of the four factor scores (Innate Ability, Certain Knowledge, Simple Knowledge, Omniscient Authority) generated for PSTs' epistemological beliefs is explained using multiple regression analysis to show how accurately they can be predicted from a linear combination of self-efficacy (factor score 1), outcome expectancy (factor score 2), and epistemological world view (factor score 3). (mean scores). We used the histogram of the standardized residuals to verify the conditions of normality, sufficient sample size, lack of multicollinearity (no correlations were found to be more than .50 among independent variables), and linearity. For each of our regression analyses, none of the aforementioned conditions were met.

Important model contributions came from self-efficacy, outcome anticipation, and epistemological world view in predicting Innate Ability component scores. Adjusted R² = 0.296, F(1, 420) = 59.94, p .01 indicates that this set of factors accounted for 29.6% of the variance in the EQ's Innate Ability component scores.

Each factor's - weight was as follows: .356 for self-efficacy, .258 for result expectation, and .235 for epistemological world view. For example, teachers with higher self-efficacy beliefs (those who think they are good teachers are more likely to believe that their students will do well in science) and higher outcome expectancy beliefs (those who think their students will do well in science are more likely to believe that their

students' learning ability is not fixed) also had lower Innate Ability factor scores (which means that those teachers who believe the effectiveness of student-centered approaches in teaching tended to see their students learning ability as not fixed). In other words, these educators recognize that kids' innate propensities for learning are malleable traits that may be fostered via strong pedagogical techniques.

The results on the Certain Knowledge component were only moderately predicted by outcome expectation. For the EQ's Certain Knowledge factor, this variable accounted for 1.4% of the variance (adjusted $R^2 = 0.014$, $F(1, 420) = 7.07$, $p .01$). For anticipated outcomes, the β -weight was .129. Although the β -value suggested a positive correlation between epistemological world view and Simple Knowledge component scores, the scoring of the questions rendered this correlation negative. Somewhat surprisingly, educators with better scores on the Certain Knowledge aspect also had higher scores on the Expectancy of Outcomes criterion (less sophisticated beliefs in Certain Knowledge). According to these results, instructors who have faith in their students' scientific aptitude tend to feel confident in their ability to influence their students' accomplishment only when the requisite scientific information is Certain Knowledge (knowledge is unchanging).

The Simple Knowledge component scores were only significantly predicted by one of the predictor variables (epistemological world view). This variable accounted for 0.8% of the variance in the EQ's Simple Knowledge component scores (adjusted $R^2 = 0.008$, $F(1, 420) = 4.41$, $p .05$). An epistemic perspective on the world has a β -weight of .102. The results for the Certain Knowledge EQ component are paralleled by an inverse connection. This study suggested that educators who value the use of learner-centered strategies in the classroom are more likely to think that science is best conveyed by having pupils remember specific facts or a broad body of information (Simple Knowledge). Unfortunately, the scores on the Omniscient Authority factor could not be explained by any of the predictor factors. The results of a multiple regression analysis are shown in Table 3.

Table 3. Analyzing the relationships between EQ factors, epistemic worldviews, and self-efficacy beliefs using a multiple regression model

EQ dimension	β weight	Adjusted R^2	F	p value
Innate Ability Self-efficacy	-.356	0.296	59.94	0.000
Outcome expectancy	-.258			
Epistemological world view	-.235			
Certain Knowledge				
Outcome expectancy	.129	0.014	7.07	0.008
Simple Knowledge				
Epistemological world view	.102	0.008	4.41	0.036

Discussion

The EQ performed adequately in identifying aspects of epistemic views. Based on our findings, it's evident that epistemological views in Asian culture are a collection of separate convictions. Determining epistemic views, both qualitatively and statistically, is a difficult undertaking. Numerous studies were conducted, as was noted previously, using a wide variety of research techniques and sample sizes. Research into this area has shown evidence for three or four distinct factor architectures. Given the wide range of component counts, it is clear that identical factor structures cannot be assumed across all possible combinations of sample features. After doing this research, we discovered four different factor configurations. This investigation

discovered the "Omniscient Authority" quality that she had not been able to uncover before. On the other hand, we did not find evidence of the "rapid learning factor."

Similar trends may be seen in the factor analysis of the Asian EQ version, which are consistent with those found by (Celik et al., 2021). The findings from this study indicate that multidimensional theory is superior than unidimensional theory for understanding the epistemic convictions of PSTs. To follow the unidimensional theory's predictions, there should be just one component at play in how PSTs' epistemic views evolve over time. We did, however, identify four converging criteria. Thus, the epistemological views of PSTs may be seen as "a collection of more or less autonomous beliefs."

The amount and variety of component structures was another thing we noticed. She observed many instances of four-factor configurations in her research. Those qualities included the capacity for rapid learning, knowledge assurance, ease of understanding, and innate skill. One of the four factor structures we discovered in the Asian sample was "Omniscient Authority." the present EQ validation investigation, our prior study also identified this component. This research sheds valuable information on the cultural variations in the educational environments of the two nations. PSTs enrolled in teacher preparation programs provide a range of perspectives to the classroom, gleaned from their varied educational backgrounds. As a result, teachers' professional growth during their training is shaped by their prior academic experiences. Many Asian educators may have used time-honored methods of instruction (e.g., expository). Pupils may have gained an understanding, through such a method of instruction, that science is a body of information found by scientists and that the purpose of instructors is to convey this body of knowledge to their students. A classroom set-up like that may have prevented our kids, at any age, from learning to think critically about the scientific information they're being taught and the methods scientists use to produce their findings. Our factor structures' seeming All-Knowing Authority might be attributable to this method. The findings of a multivariate regression study showed a negative correlation between the EQ's Innate Ability factor and self-efficacy, outcome expectation, and worldview. These inverse correlations suggested that preservice educators (a) have higher levels of self-efficacy in their science teaching, (b) are more confident in their ability to influence their students' achievement, and (c) hold a more relativistic epistemological perspective the less they believe in Innate Ability. According to this research, PSTs are confident in their capacity to teach science if they acknowledge that students' innate aptitude for learning is not static, but rather an ever-evolving trait of learners who can be nurtured via good pedagogy. This result agrees with a recent synthesis of research on the connection between epistemological ideas and education (Celik et al., 2021). "epistemological views determine the degree to which individuals: (a) actively participate in learning, (b) persevere in difficult activities, (c) absorb textual material, and (d) deal with ill-structured domains," she writes. According to research (Eccles & Wigfield, 2020), students who scored higher on the "Persist in difficult task" scale were more likely to be incremental theorists, who believe that an individual's intelligence can be developed over time, or fixed theorists, who believe that their ability to learn is fixed. As a result, they have different priorities when it comes to doing a school project. The incremental theorists engage in intellectual pursuits with the goal of improving their intelligence, whereas the fixed theorists attempt to demonstrate their own brilliance. Our research shows that proficient science teachers (PSTs), who see learning as a dynamic process in which students actively participate, may promote student learning and contribute to the enhancement of their cognitive abilities via the use of sound pedagogical strategies.

Results from a multivariate regression study revealed a negative significant association between "certain knowledge" and just "outcome expectations." This correlation shows that the acceptance of scientific information as immutable scientific results is necessary for preservice teachers to feel confident about affecting students' progress (outcome expectation) (Certain Knowledge). Teachers worry that if they present scientific information as dynamic and always evolving, their pupils won't retain much of it. Only world perspective was shown to have a significant (positive) connection with scores on the Simple Knowledge dimension among the investigated variables. These intriguing findings suggest that PSTs have faith in the efficacy of student-centered teaching methods (relativist world view). They also acknowledge that memorization of specific facts or a body of scientific information may be the most effective method of teaching science (Simple Knowledge).

Multiple fascinating findings were uncovered by the predictors of the Certain Knowledge and Simple Knowledge dimensions. In the first place, our results about Innate Ability, Certain Knowledge, and Simple Knowledge provide credence to an argument concerning the formation of an individual's epistemological convictions. I advocated for a rethinking of epistemological beliefs as a system of disjoint convictions, she explains. When I say "system," what I really mean is that there are different points of view to weigh. When I say that people are "more or less autonomous," I mean that they may be "sophisticated" in certain ideas but not necessarily in other views. The participants' ideas on the dimension of Innate Ability were somewhat complex, those on the dimensions of Certain Knowledge and Simple Knowledge remained quite simplistic throughout the course of the research.

Second, PSTs worry that their students won't learn anything if they frame scientific ideas as fluid, ever-evolving scientific understandings, which is how they see them. In other words, if they perceive scientific knowledge as being continually changing, preservice teachers fear they would fail in their teaching of science. Further, they are confident in using student-centered teaching approaches and implementation only when students correctly recall the isolated facts or body of scientific information. In addition, this result lends credence to the "comprehend written material-integration of knowledge" dimension of the synthesis (Celik et al., 2021) about the connection between epistemological ideas and education. Students may be categorized into two groups based on their preferred method of studying science: (1) static believers, who find that memorization of words and facts is the most helpful, and (2) dynamic believers, who find that learning science best occurs via active participation in the subject. The latter group has advanced more in its epistemological thinking. Our research suggests that PSTs may see their students as unmoving believers when considering how to provide scientific ideas and data. During their education, PSTs are taught the same way as static believers, as was indicated above. The result might be a mistaken assumption that their potential pupils are not as vibrant in their faith as they themselves are. Research by Fischer et al. (2018) shows consistent findings. Teachers' perceptions that they are able to use constructivist pedagogical strategies in the classroom were shown to be positively influenced by their self-efficacy ratings. Contrarily, 81% of instructors did not think it was useful to use constructivist tactics in their science classes while teaching science using constructivist ideas. It has been proposed (Fischer et al., 2018) that educators are inclined to lecture while instructing their students in the sciences since that was how they were trained. Teachers believe this because they have been raised to believe that science is a collection of discrete facts and ideas that can be efficiently transferred to pupils via memorization and lecture. To the finding of (Fischer et al., 2018), our research provided a student perspective. PSTs in this research think that they can only use student-centered strategies if they have a fixed conception of their students' belief systems. According to these results, allowing dynamic believers to study in student-centered settings might lead to an unruly classroom. PSTs would have a hard time keeping up with the kids' progress in this lesson. Thus, PSTs have faith in the efficacy of student-centered instruction, but they worry about their own abilities in the classroom. Ultimately, they arrived with a fascinating theory. This theory holds that a student-centered approach can only provide positive results if the students themselves are firm believers. In other words, the responsibility of a student in a science class is to remember and understand the material presented using techniques tailored to the needs of the individual student. Tawfik et al. (2018) observed the same thing; even while instructors said they were convinced of the efficacy of student-centered methods, they mostly employed district-mandated curricula and expository methods in the classroom. Based on these results, it seems that there are separate issues to explore regarding the beliefs of PSTs and their use in the classroom.

Conclusion

The epistemological beliefs of PSTs were identified, and the links between epistemological worldviews, self-efficacy, and other epistemological belief aspects were investigated. This research uncovered serious problems with how teacher preparation programs are preparing future teachers to effectively administer scientific instruction for PSTs. The findings, PSTs' epistemic convictions evolved into more or less autonomous convictions during the course of the study. Thus, whereas PSTs acquire complex views in certain epistemological aspects (such as Innate Ability), they develop less sophisticated beliefs in other epistemological dimensions (e.g. Certain Knowledge, Simple Knowledge). There are two key points to keep in mind from this

finding. In the first place, the findings of the factor analysis showed that epistemological beliefs in Asian culture are a collection of four component structures that are mostly distinct from one another. That is to say, PSTs have a wide range of epistemic convictions. Where a result, it is crucial for teacher preparation courses to focus on identifying teachers' underlying beliefs and helping them grow, as appropriate, because of the impact such beliefs have on their students' education. Several studies have shown that a person's beliefs significantly affect their ability to perceive and integrate new knowledge, their motivation for and success in school, and their assessment of their own learning. It's crucial for a person to be aware of his or her own epistemological growth in order to focus on improving his or her own epistemological views. If this individual happens to be a teacher, the problem is much more pressing because of the impact the instructor has on their pupils. According to (Celik et al., 2021), educators who are aware of their students' underlying epistemological assumptions are better equipped to design lessons that will propel their students from lower to greater levels of achievement. Teachers can only help students if they have themselves developed in this way. This will make it less of a stretch for them to use the same methods with their kids. This is largely possible thanks to the efforts of teacher preparation programs. The classroom educators have a significant impact on students' learning outcomes in science. How they educate will undoubtedly be influenced by their own epistemological views. According to our research, when it comes to imparting scientific information to pupils, PSTs consider their efforts to have been effective only if their charges are able to commit key scientific ideas and facts to memory. They argue that pupils should remember a set of predetermined facts and ideas. They worry that their pupils are not learning and using student-centered teaching approaches if they do not remember these facts and ideas. This tension must be resolved throughout their training as educators. This should be accomplished through both theory sessions and practical teaching experiences. PSTs need chances to try out student-centered approaches and see how they affect students' learning and the formation of their epistemological convictions. Similar concerns were also noted in a recent research (Fischer et al., 2018). As they put it, "Teachers need to see constructivist practices demonstrated" in order to have faith in the impact constructivist ideas have on students' education. They need time to try out the methods of instruction, evaluate their own performance, and have meaningful conversations with their peers (Fischer et al., 2018).

Implications

Our recommendations for the training of PSTs are shown below. The goal of teacher training programs is to produce more effective educators who will be able to adapt their classroom practices to reflect the realities of a rapidly evolving global society. For teachers to be effective, it is thought that they must have a firm grasp of their own personal values and the ways in which these inform their teaching methods (Tawfik et al., 2018). Epistemological beliefs, epistemological world views, and self-efficacy beliefs are examples of such views. Based on our findings, PSTs seem to have less developed epistemic convictions. Furthermore, it is discovered that epistemological world views and self-efficacy beliefs affect these convictions. Teacher educators have a responsibility to guide students toward self-awareness and, if required, belief revision. These include, but are not limited to, claims of epistemological certainty. Preservice teachers sometimes struggle to alter their worldviews throughout their training since their opinions and ideas have been formed over such a lengthy period of time (Howard et al., 2021). PSTs require a methodical strategy to assist them upgrade their simplistic worldviews. Teachers' epistemological ideas might be shaped by a variety of classes they take in teacher school, including those on the nature of science, the philosophy and history of science, and scientific teaching techniques. PSTs may benefit greatly from completing additional scientific courses in order to increase their depth of understanding. However, via classes like nature of science and philosophy and history of science, one may learn about the processes by which scientific information is uncovered and refined, as well as the epistemology, scientific method, scientific principles, and their implications. PSTs should be incentivized and supported in their pursuit of these courses. This highlights the need, for teacher preparation programs, of focusing on the formation and maturation of PSTs' epistemic views (Vosniadou et al., 2020).

We suggested up top that PSTs' epistemological convictions may be influenced by courses in scientific education approaches. These classes may provide PSTs a framework for understanding the relationship between their own epistemological convictions, worldviews, and sense of competence. PSTs may be able to recognize

their epistemological beliefs and examine how those beliefs shape their epistemic world views throughout scientific education techniques courses. Our research shows, for instance, that PSTs adopt a relativist worldview while holding less complex views about Simple Knowledge and Certain Knowledge. PSTs, in light of these seemingly mutually exclusive worldviews, established an intriguing pedagogical strategy in which they favored student-centered techniques if their pupils saw science as unchangeable and memorized scientific facts. This discovery showed that PSTs gain knowledge of the theory (various pedagogical approaches and the ideas that underpin them), but are unable to use this knowledge in practice because of their simplistic worldview. PSTs taking science education methods classes will get an understanding of the challenges associated with implementing student-centered approaches if their pupils believe science to be unchangeable and need rote memorization of scientific information. Throughout their microteaching and field experiences, they should be discussing the theoretical knowledge, their execution, and the implications of their epistemological views on these activities in order to establish a connection between theory and practice.

It is possible that PSTs' exposure to the classroom environment via fieldwork can help them better comprehend the practical application of educational theory. Field experiences in schools provide future teachers a chance to test out their identity and knowledge, as stated by (Alt, 2018). But it is well-known that PSTs seldom put into practice the ideas they studied in their teacher preparation courses (Cochran- Smith, 1991). Now is the time to create and support collaboration between schools and universities so that PSTs might have a chance to alter their epistemic convictions.

There have been a lot of research done to try to figure out what goes into shaping a student's epistemological ideas. The formation of teachers' epistemic convictions and worldviews is a topic of little investigation (Tawfik et al., 2018). This study highlights the need for more investigation into how PSTs' epistemic convictions and worldviews might be strengthened.

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