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RESEARCH ARTICLE

Mapping the Interrelations between Pre-service Teachers' Beliefs and Knowledge of Learning to Their Principles of Effective Instruction

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Abstract

This mixed-methods study examined the congruence of pre-service teachers' perceptions about their beliefs and knowledge of learning to their perceived principles of effective instruction, explicitly linking learning and teaching for students and teachers. Participants were 56 pre-service teachers in the college of education at a mid-sized university in the southeastern US. Three measures were employed in this study: firstly, participants were asked to choose a picture that best represented their views on the relationship between beliefs and knowledge and two open-ended questions asked them to define what beliefs and knowledge are. The second measure consisted of twenty-four items asking about their perceptions of their knowledge and beliefs about learning. Finally, the third measure consisted of an open-ended item asking participants to list and briefly describe their five core principles of effective instruction. Results show that beliefs are relatively dynamic and subject to change. Even over the course of a semester, there was a qualitative shift in pre-service teachers' perceptions of knowledge of learning and less so in terms of perceptions of beliefs about learning. Surprisingly, there was less change in PSTs' beliefs about learning, which is important since these beliefs may be much more likely to influence their decision-making as both pre-and in-service teachers.

Keywords: Beliefs and knowledge, knowledge of learning, pre-service teachers, principals of instruction

Introduction

The lack of integration between theories of learning and theories of teaching has been suggested as one obstacle to developing teachers' capacity to implement more effective teaching strategies based on the learning needs of students (Vermunt & Verloop, 1999). While there are numerous studies and lines of research that examine teachers' beliefs about teaching (Buehl & Fives, 2009) and their professional identity (Beijaard et al., 2000), less is known about how teachers' beliefs about knowledge and their students' learning change over time, particularly with regard to pre-service teachers (Parkinson & Maggioni, 2017). This is important, as an enhanced understanding of pre-service teachers' perceptions about their beliefs and knowledge regarding learning and instruction may further inform our understanding of how these perceptions will translate to teacher decision-making and how these understandings develop over time and influence their classroom practice.

Literature Review

At the heart of most teacher preparation programs has been an attempt to develop pre-service teachers' understanding of how students learn and what instructional strategies will best facilitate that learning (Ball et al., 2008; Shulman, 1986). Thus, the interrelations in this framework explore two distinct sets of theories: theories of learning and theories of teaching. Additionally, we examine how beliefs about learning might differ from knowledge about learning. Secondly, the framework describes the development of articulation between these two theories for pre-service teachers.

Theories of Learning

Theories of learning describe how learning takes place. While a variety of perspectives on learning exist (Schunk, 2008), the focus of this study was on six influential theories in terms of their impact on both research and practice.

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The first of these theoretical perspectives are strict behaviorism (Skinner, 1965) which describes learning as a change in behavior explained by environmental stimuli. In classical conditioning, behaviors are shaped when neutral stimuli are associated with unconditioned or previously conditioned stimuli to train a conditioned response (Pavlov, 2003). In operant conditioning, contingent consequences that occur after a behavior either increase the behavior (reinforcement) or decrease a behavior (punishment; Skinner, 1965). The second perspective, a neo-behaviorist perspective, is social-cognitive theory (Bandura, 1986). The social-cognitive theory places emphasis on learning about the change in behavior, however, makes two radical departures from the stricter views of behaviorism by Watson and Skinner. First, changes in behavior are not due solely to environmental stimuli with mental processes (personal determinants) playing a key role in learning. Second, the relations between person, environment, and behavior are reciprocal, meaning that not only is behavior a consequence of both personal and environmental determinants, but behavior can also change a person's mental processes and nature of their environment.

Two more recent perspectives of learning that have garnered the majority of attention, particularly in colleges of education are cognitive constructivism (Piaget, 1964) and social constructivism (Vygotsky, 1980). Instead of focusing on the role of behavior, these two constructivist approaches focus on the construction of mental schema (Schunk, 2008). Piaget proposed that knowledge was assimilated (added) and accommodated (changed) through a process of equilibration whereby an initial schema was reconstructed based on some discrepant event that an individual experienced. Thus, new experiences and discoveries through these experiences were crucial. Vygotksy, on the other hand, argued that this process of equilibration was possible for what he labelled *spontaneous concepts* (concepts that could be learned through discovery or experimentation), however, for children to learn *non-spontaneous concepts* (those concepts that could not be learned through experimentation or discovery) language and social interaction were necessary tools through processes of internalization and self-regulation (Vygotsky).

The advent of computers and artificial intelligence in the 1970s brought about more cognitive approaches such as information-processing approaches (Simon, 1978), which stipulate that the goal of learning is to move knowledge and memories to a long-term memory store. This typically involves processes to make meaning of new information (attention and perception) and encode that information (rehearsal or elaboration) for longer periods of time to be retrieved later. Finally, sociocultural approaches (Rogoff, 1990) were a direct reaction to these more cognitive approaches and placed the emphasis on knowledge *in-situ* (the contexts in which students actually learned). Socioculturalists argued that elements such as language and cultural practice cannot be removed from descriptions of learning and rather focused on apprenticeships of thinking (Lave & Wenger, 1991).

Beliefs about Learning

It is important to recognize the ongoing debates about these theories (Alexander et al., 2009) and how individuals might hold all or parts of these theories to be congruent or incongruent with each other. Thus, beliefs about the validity of a theory and having knowledge about that theory may cause teachers to operationalize this knowledge and beliefs in unique ways. This distinction between one's perceptions about their beliefs and knowledge about learning (Yıldırım & Maltby, 2022) is critical since epistemically some individuals see beliefs and knowledge as distinct, while others see them as completely congruent (Alexander & Dochy, 1995). This distinction is particularly salient in terms of teaching, since many models, such as the naturalistic teacher decision-making model (Cornett et al., 1990) emphasize the role of core beliefs about teaching as the main source of teachers' strategic actions in the classroom.

Principles of effective instruction

Over the years, researchers have written a lot about what constitutes effective instruction and the shared consensus was that effective teaching is meaningful to students, and it leads to personal and academic growth. For learning to be meaningful, it needs to appeal to the students, to make them want to invest their time and energy to pursue certain topics inside and outside of class. Some of the most common principles that make learning meaningful are: using student strategies; establishing connections with real life; and embedding students' interests and culture into class.

Student-centred strategies

To achieve educational equity and excellence, Gay (2010) urged teachers to employ a variety of resources and teaching techniques (i.e. cooperative learning strategies, discussions, etc). Cooperative learning has long been

deemed an essential tool for effective instruction because cooperation and collaboration are prominent in educating marginalized students. Similarly, researchers (Gillies, 2014; Slavin, 2014) believed that cooperative learning forged more interethnic social interactions and friendships and it increased academic achievement, resulting in higher levels of confidence and efficacy for students of color, better engagement and learning tasks, and intrinsic motivation. In addition, group work and class discussions moved students from passive to active modes of learning (Powell & Casseau, 2004). Small group work increases problem-solving and critical thinking skills, social skill development, and the students' cultural sensitivity. Similarly, Green (2022) emphasized the need for teachers to explain fundamental concepts through practical examples, activities, and/or videos, urging educators to select the most suitable teaching strategies (e.g., individual, pair, or small group tasks, short research papers, etc.).

In the same vein, Tanase (2020a) found that when teachers involved students in hands-on activities and discovery learning in their mathematics and science classes, this collaboration increased student accountability, as students taught each other, and they expanded their learning. For example, when working in groups to create their dream bedroom, testing the enzyme activity on chicken livers, using candy to learn about water molecules, or doing gallery walks, students developed their critical thinking and social skills. In addition, group work leads to increased academic performance and cultural sensitivity (Gay, 2000; Powell & Caseau, 2004). The use of review games (i.e. basketball review game for math), online games (i.e. Cahoots; Math Excel; Cool Math), and/or different manipulatives (i.e. cards puzzles, dice) was related to increased academic performance, as students learned while having fun.

Establishing connections with real life

Researchers have discussed the significance of teaching content relevant to their students' lives. For example, Hernandez et al. (2013) discussed some effective strategies mathematics and science teachers used to make connections to students' everyday lives. These teachers used real-world examples (i.e. rocks, plants, or clocks) when introducing new or difficult concepts, and they modelled to illustrate difficult science and math concepts. Similarly, Kelly-Jackson and Jackson (2011) described how a science teacher built a community of learners, as his students collaborated on tasks that were relevant to their lives and interests. In addition, Green (2022) discussed how the content embedded in real-life stories, the situations depicted in video clips, and related experiential activities may further students' self-esteem, as students learn to handle obstacles on their own, they identify solutions and find creative ways to deal with different problems. This eventually leads to personal growth.

Similarly, Tanase (2022) explained that culturally responsive teachers used community assets to teach their students different concepts in mathematics and science**,** making their students' real-life experiences part of the official curriculum. Classrooms become communities of learners where students work together to learn the content and they develop a critical consciousness about issues and events that occur in their own communities. To connect mathematics and science content with real life, the teachers used examples of common things, like food, water, money, etc. For example, science teachers used food analogies to make the content more meaningful: when teaching about carbohydrates, lipids and proteins, teachers discussed the importance of a healthy diet, they encouraged students to keep a food diary to analyze the macromolecules in the foods they consumed, and to encouraged them to study nutrition labels. In other classes, students used gummy bears and marshmallows to build water molecules or used pizza or cookies to learn about fractions.

Tanase (2022) further explained how science teachers used examples of water to make the content relevant, such as discussing how the rain affected the environment, or relating water properties to beverages (i.e. lemonade, Kool-Aid). In addition, the Tanase discussed how mathematics teachers used the money to do financial math, teaching students how to balance a checkbook, incorporating money examples in word problems (i.e. deciding which cell phone plan is better for data; learning about gas/mileage cost), or incorporating their students' interests in sports shoes (i.e. such as going to the store and buying Jordans). And since teachers believed that energy is all around us, they used energy, weight, and mass examples. Students learned about energy transformation (chemical to electrical energy), heat (conduction, convection, radiation), or while on nature walks on their school campus, they learned about the organisms that lived within that ecosystem. When teachers apprentice their students in a learning community, rather than teaching them in unrelated ways, the students' real-life experiences can become part of the official curriculum (Ladson-Billings, 2009).

Using students' interests and culture

Learning becomes meaningful when teachers develop their lessons around their students' interests. Kelly-Jackson and Jackson (2011) believed that an ideal science curriculum included the students' interests, allowing students to generate ideas and set goals for themselves. In turn, students are motivated to master the skills necessary to reach their goals. Goldston and Nichols (2009) also addressed the benefits of using students' interests in science, urging science education researchers to "explore ways of teaching science that utilize local community knowledge and student interest" (p. 196), while Boutte et al. (2010) believed that "science involves inquiring into one's own world" (p. 11).

In addition, Tanase (2022) discussed the benefits of incorporating students' hobbies into lessons, as they demonstrated mastery of academic content. For example, teachers appealed to their students' passion for sports, and they devised problems that included sports examples (i.e. using football terminology, basketball and tennis inbound or out-of-bounds examples to teach the difference between less than and equal to). In addition, teachers incorporated their students' interest in dance and music using the cha-cha slide to teach about mathematics translations, and the Evolutions of Dance video to teach about evolution. Students' interest in genetics was addressed when discussing evolution, skin color, and adaptation to the environment. Other teachers appealed to their students' interest in social media (using memes in their lessons) or in their interests in social justice issues (i.e. taking a knee during the national anthem/the Pledge of Allegiance; the Black Lives Matter movement).

And since "The communities in which students live are a significant component of their culture" (Tanase, 2020b, p. 12), the researcher explained how teachers embedded community examples in their lessons, such as using the church analogy to teach about cells, or introducing them to role models they could relate to, such as the African American or African scientists (Neil Degrasse Tyson, Greg Washington Carver), because the curriculum continued to exclude marginalized groups (Gay, 2010; Howard, 2010). Ultimately, teachers need to help their students determine the implicit perspectives embedded in curriculum materials in order to become more reflective citizens (Banks, 2011), and to learn information about "gender contributions, issues, experiences, and achievement effects within ethnic groups" (Gay, 2018, p. 192).

The framework we used to understand the teaching perspective was Ball et al.'s (2008) multidimensionality of the knowledge of teaching. The researchers found the following domains pertaining to teacher knowledge: common content knowledge (knowledge and skills used in setting other than teaching); specialized content knowledge (knowledge and skills unique to teaching). As an extension to Shulman's (1986) interpretation of pedagogical content knowledge, Ball et al. added the following two domains: knowledge of content and students (knowing about students and knowing about your subject), and knowledge of content and teaching (knowing about teaching and knowing about your subject).

Congruence of learning and teaching theories

Constructivist educators view learning as an ongoing and active process, in which students construct knowledge from interpretations of their interaction with the environment (Awan & Khan, 2014). Teachers must pay special attention to what their students already know (Calik et al., 2010), as students' perception of the world, which is based on their everyday life experiences, and the knowledge which results from this perception may be skewed (Awan & Khan, 2014). The outcome of this interaction with the environment is often a conceptual change in students' beliefs. Conceptual change is a process of learning that describes modifications in existing conceptions or beliefs (Awan & Khan, 2014; Gregoire, 2003).

Cognitive and social constructivists contend that learning for conceptual change does not merely imply the accumulation of new facts or skills; on the contrary, it implies changing an existing conception or misconception (Awan & Khan, 2014). When students realize that their current understanding is flawed, they experience cognitive conflict. This disequilibrium pushes students to make meaning for themselves (Piaget, 1964) and to seek to eliminate the discrepancies between new and old information (Gregoire, 2003). In addition, with the help of a peer or teacher, the student can move from their current level of understanding outside of their Zone of Proximal Development (Vygotsky, 1980). The benefits of (promoting) conceptual change lie therefore on the student-instructor and student-student interaction along with the student's own efforts to changing their misconception (Awan & Khan, 2014).

Conceptual change involves four steps: 1) eliciting students' pre-existing ideas, 2) focusing on the target concept, 3) challenging students' ideas, and 4) applying newly constructed ideas to similar situations (Calik et al., 2010).

In higher education, teaching for conceptual challenge creates further dilemmas for educators (Grierson, 2010), who present new information in ways that provoke teacher candidates to question their existing conceptions, all the while supporting them to perceive new conceptions as plausible (Gregoire, 2003). Loughran (2006) also described this double challenge for teacher educators, as they must simultaneously teach the content of their subject area and teach people how to be reflective, responsive, and adaptive to the capricious situations that arise in the classroom. Because teachers and teacher educators actively challenge their students' ideas, teaching for conceptual change does not come without challenges, as some beliefs are resistant to change (Calik et al., 2010). On the other hand, students can hold more than one conception at a time (Awan & Khan, 2014), and these conceptions can be enhanced or changed (Awan & Khan, 2014; Park & Han, 2002). In addition, Waters and Higgins (2022) discussed the impact of teacher language on students' understanding of their own capacity to change: the type of feedback the teachers provide (i.e. general or specific) may lead to students adopting a fixed or growth mindset.

Development of teachers' knowledge and beliefs about learning and instruction

Exposure to course materials, activities and classroom discussions may alter pre-service teachers' beliefs about learning and teaching. Researchers (Tannehill & McPhail, 2014; Sellers, 2004) argued that only when opportunities are created in the teacher education and training programs in which pre-service teachers' perceptions are challenged, their beliefs will change. When pre-service teachers become part of powerful experiences in which they analyze effective practice teaching videos, reflect on their own teaching metaphors and are engaged in problem-solving, they become active problem solvers who will foster constructivist learning environments in their classrooms (Ineson et al., 2015; Sellers, 2004). Yet, however much necessary exposure to student-centred environments may be, is not a guarantee for a change in pre-service teachers' beliefs, as some researchers reported that while certain beliefs became elaborate, others were resistant to change (Borg, 2005). Nevertheless, as researchers pointed (Sellers, 2004; Tanehill & McPhail, 2014), teacher education programs must be the place where pre-service teachers are confronted with and exposed to diverse perspectives through the experiences their professors create in the courses they teach. This change will not take place without the challenge and discomfort created by learning environments that foster critical thinking and problem-solving

On the other hand, teachers' epistemological beliefs continue to be influenced while in-service, through professional development opportunities. Researchers reported significant positive impacts on teachers' knowledge for teaching, their own beliefs about the subject matter they teach, as well as about the use of student-centered approaches as a result of a year-long mathematics professional development (Arce et al., 2014). Similarly, Franke and Kazemi (2001) reported significant growth in the development of teachers' identities, as well we the impact a cognitively guided instruction approach had on their classroom practice, as the teachers shaped their classrooms as group-work communities and saw them as places for experimentations and for their own growth.

The Current Study

The purpose of the current study is to link pre-service teachers' perceptions about their beliefs and knowledge of learning to what they consider to be their principles of effective instruction, thus making an explicit link between learning and instruction. To examine these interrelations over the course of a semester we utilized a sequential explanatory design (Creswell & Clark, 2017). For the initial quantitative step, we collected data to investigate the following question: 1) What are preservice teachers' conceptions of knowledge and beliefs and how do these beliefs change over time? This was possible given the existing literature which enabled us to design relevant quantitative surveys. However, for the next step we relied on qualitative data since there was less existing research on which to base the following question: 2) How do pre-service teachers' perceptions of knowledge and beliefs about learning influence their core principles of instruction? The qualitative responses to this second question were related back to the quantitative findings in question one to deductively test the relation between knowledge and beliefs and inductively build a theory related to how the relationship between their knowledge and beliefs relates to their core principles of instruction. We used Ball et al.'s (2008) multidimensionality of teaching framework, assigning their responses to the core principles of instruction to one of the following categories: a) knowledge of subject matter, b) knowledge of pedagogy, c) knowledge of students, d) knowledge of classroom management, and e) teacher affect. Both authors were involved in the data collection and analysis, with the first author leading the qualitative data

analysis process, and the second author taking the lead on the analysis of the quantitative data. Data analysis is substantiated through triangulation (James & Augustin, 2018), a process undergone with multiple researchers, thereby upholding the quality of data analysis. For triangulation purposes, each author first coded the data individually, then we discussed the similarities and inconsistencies in the categories, and finally reached a consensus about the data categories.

Method

Participants

The primary participants of this study were fifty-six undergraduate students (81% female and 83% Caucasian) enrolled in a teacher preparation program from a mid-sized university in the southeastern United States. These preservice teachers (hereon PST) had an average age of 22.0 (*SD* = 5.9) years with an average GPA of 3.27. These demographics are typical of students enrolled in the teacher education program. Most of the students were in their third year of college (73%). Some students overlapped, taking both courses with the two researchers, while the other participants were exposed to the same theories in the courses taught by other instructors.

Measures

Three measures were employed in this study. First, the participants responded to items relating to their epistemic beliefs about knowledge. They were asked to choose a picture that best represented their views on the relationship between beliefs and knowledge (Alexander & Dochy, 1995) and two open-ended questions asking them to define what beliefs and knowledge are. These items were qualitatively coded using existing coding schemes (Alexander et al., 2012).

The second measure consisted of twenty-four items asking about their perceptions of their knowledge and beliefs about learning. There were 4 items for each learning theory discussed in the theoretical framework. For example, one of the behaviourism items read, "Individuals' behavior can be shaped solely by the environment." On a sliding scale between 0 (strongly disagree) and 100 (strongly agree) participants were asked to rate their agreement in terms of how much they believed that statement and how much they knew that statement. The researchers analyzed this measure quantitatively using exploratory factor analysis and repeated measure analysis of variance (see the first two measures in Supplementary Materials). Finally, the third measure consisted of an open-ended item asking participants to list and briefly describe their five core principles of effective instruction. This item was analyzed qualitatively using Ball et al.'s (2008) multidimensionality of teaching framework.

Table 1. Coding categories for beliefs

Variable	Definition	Example
Way of life	Beliefs are ideas or opinions that one regards as true	PST 17: "If I believe something, it helps to build my morals, and shapes who I am as a person." PST19: "A belief is something you know to be true, and something that is applied to your life as it influences your decisions and motivations in life." PST39: "Beliefs are something that you know to be completely true and something you choose to apply in your daily life." PST40: "A belief is an opinion or a feeling."
	Beliefs are ideas/feelings	PST55: "A belief is an intrinsic feeling that guides you to do whatever you think is the right thing to do."
	Beliefs are faith/trust	PST27: "A belief is having faith that something is true." PST7: "A belief means you have trust or faith in something or someone." PST23: "A belief is something you personally have faith in, support, or agree with." PST33: "A belief for me is something that has spiritual/religious value or significance."

Accepting without truth or evidence	Beliefs are a truth that may lack tangible proof	PST42: "A belief is something that you don't necessarily have much information about, but you still think highly of." PST2: "A belief is something that does not necessarily have proof of existing but it believed to be true anyway."
	Beliefs hold value; one is passionate about them, despite the lack of a tangible proof	PST5: "A belief is something that you have a strong connection with even if what you know doesn't make sense to what you believe. Kind of like religion, I guess. I feel that my beliefs are more like my morals."
	Beliefs are inner feelings	PST53: "A belief to me is something that you value and have a strong sense of passion for." PST52: "Something that you may not have seen personally but you have faith in it and this comes from you and no one else." PST5: "I feel that my beliefs are more like my morals."
Acquired from experience	Beliefs are directly influenced by acquiring knowledge	PST3: "A belief is something you feel is right or wrong using things you have learned." PST6: "To believe in something is to have an opinion about something based on facts and the knowledge I have learned on that topic."
	Beliefs are formed when one draws their own conclusions	PST29: "I think having a belief means having knowledge of something and with that being able to create your own opinion on that topic." PST47: "A belief is our opinions and interpretations of knowledge."
	First-hand experience with certain ideas is important	PST30: "A belief is something that you know but perhaps on faith or via personal experience and less than textbook knowledge. PTS8: "For something to be a belief, I think it has to be something that you agree with because you have experienced it firsthand. It isn't something someone just told you."
	Beliefs emerge from family values	PST51: "A belief is a viewpoint of the world that I have developed through prior experience." PST15: "My belief is something true to myself. Things that correlate with what I have been raised with and what my parents have taught me." PST21: "Something that you have been raised on and firmly believe to be true." PST26: "A belief is how you feel about something usually based on who raised you or the people you surrounded yourself with."

Procedure

All three measures, in addition to a demographic questionnaire, were given to students at the beginning and end of one of two semester-long courses in a teacher preparation program. These two courses were purposefully selected, as they both incorporated theories of teaching and learning: EDF 3151 (Educational Psychology) discussed theories of learning, and EDG 3323 (The Learning Process) discussed theories of teaching. The two researchers were teaching these courses at the time this research was conducted. There were 4 sections of EDF 3151 offered in the semester the study was conducted, and the second author taught two of these sections. There were two sections of EDG 3323, and the first author taught both sections. The study was conducted after obtaining IRB permission from the university.

Results

Pre-service Teachers' Conceptions of Knowledge and Beliefs

The first step in the quantitative analysis of preservice teachers' knowledge and beliefs was to code the responses into Alexander et al.'s (2012) categorization. Similar to Alexander et al.'s previous findings, the participants' definitions of beliefs matched one of three categories: (a) a way of life that influences decisions, (b) accepting

something without truth or evidence, and (c) acquiring knowledge from experience. Table 1 includes the three definitions and examples from the dataset for each of the three categories.

Table 2. Changes in beliefs from pre- to posttest

Variable	Pre-test	Post-test
Way of life	25	17
Accepting without evidence or truth	18	11
Acquired from experience	13	9

Each of the below categories was evident at both pre and post-test. Table 2 presents totals in these categories at both the pre-test and post-test. From pre to post-test there was a slight shift towards the view that beliefs were accepting something without truth or evidence, although there certainly were numerous examples of PSTs that were consistent across the course of the semester with their definitions: a way of life (n=10), accepting without evidence (n=4), and acquired from experience (n=5). For knowledge, there were again similarities to Alexander et al.'s (2012) categories: (a) knowledge acquired from sources, b) knowledge gained through experience, (c) information you can explain to yourself and teach, and (d) something that has real-life application. Table 3 includes the definitions and examples from the dataset for each of these categories. Since some participants coupled the knowledge acquired from sources with the knowledge gained through experience, we grouped these two categories together.

Table 3. Coding categories for knowledge

Variable	Definition	Example
Knowledge acquired from sources or through experience	Knowledge is gained from experience or learned from different sources (it can be proven right or wrong)	PST 35: "Knowledge is factual. It can be proven wrong or right." PST5: "Knowledge is information that you acquired either in a factual situation or something that you adapted/learned from an experience."
	Something becomes knowledge when accredited by reliable sources	PST30: "Knowledge is more concrete, it is typically of something that can be observed or that comes from a respected source. I view knowledge as fact-based, rather than opinion based." PST13: "For something to be knowledge for me, it has to be backed up by creditable sources."
	Knowledge is something that can be proven as a fact, regardless of whether one agrees with or believed that fact to be true	PST10: "It is the things that you are aware of. It is the understanding you have of something, regardless of if you actually believe it is fact." PST1: "Knowledge is something that you know, like facts. When you learn new things, you gain knowledge. You don't have to agree with it for it to be knowledge." PST8: "Knowledge is anything you have acquired, whether through someone telling you or you finding it out yourself. You don't need to agree with knowledge, but you accept it."
Information you can explain to yourself and teach	Acquired knowledge is valuable when one can explain it to the others	PST53: "Knowledge is an understanding of something new or a better understanding for something you have previously acquired. You can apply it to experiences in your life and share it with others." PST14: "Knowledge is being able to explain what you know on to someone else." PST18: "For something to be knowledge, the information has to be understood with detail to a point where it can be explained."

Real-life application	Knowledge is something that one upholds as true, and that helps one make choices in life	PST 55: "Your understanding of something that you believe to be true and the ability to understand and integrate it into your life." PST26: "Knowledge is when you benefit from what someone has said or done that impacts you." PST41: "When I am able to develop new thoughts and ideas, after learning something and I can carry them with me throughout my life or use it in everyday situations, I feel that I have gained knowledge. I think a good part of my knowledge are ideas that have been stored in my long-term memory. They are the ones that have had relevance or meaning to my life."

From pre to post-test there was a slight shift towards the view that beliefs were accepting something without truth or evidence, although there certainly were numerous examples of PSTs that were consistent across the course of the semester with their definitions: way of life (n=10), accepting without evidence (n=4), and acquired from experience (n=5).

Table 4. Changes in beliefs about knowledge from pre- to posttest

Variable	Pretest	Posttest
Knowledge acquired from sources or from experience	41	11
Information you can explain to yourself and teach	9	8
Real-life application	6	4

For knowledge, there were again similarities to Alexander et al.'s (2012) categories: (a) knowledge acquired from sources, b) knowledge gained through experience, (c) information you can explain to yourself and teach, and (d) something that has real-life application. Table 3 includes the definitions and examples from the dataset for each of these categories. Since some participants coupled the knowledge acquired from sources with the knowledge gained through experience, we grouped these two categories together.

Table 5. Pre-service teachers' perceptions of their beliefs about learning at the pretest

	Component							
Items about Learning	1	2	3	4	5	6	7	8
Stimuli can be associated with one another to influence behavior. (Beh)	**.76**	.15	-.02	.05	-.26	.03	.29	-.15
Learning consists of children incorporating social activities into their thoughts. (SocCon)	**.54**	.16	.01	.29	.02	.29	-.06	.08
Knowledge can be divided up into declarative, procedural, and conditional knowledge. (IP)	**.73**	.04	.15	-.31	-.11	.05	.05	.34
Both personal and environmental factors can shape behavior. (SCT)	**.53**	.39	.19	.45	.20	.10	.13	.00
Cultural tools vary from culture to culture. (SCult)	.18	**.74**	.05	.00	.05	-.03	.08	-.10
Learning occurs when children are engaged in relevant cultural activities. (SCult)	-.03	**.73**	-.23	.06	-.15	.12	.07	.15
Information is encoded more easily when it is associated with prior knowledge. (IP)	.07	**.78**	.29	.13	.12	.04	.13	.07
Reinforcement increases a person's behavior. (Beh)	-.05	.23	**.72**	.15	-.16	.18	.15	.18
Learning occurs only in authentic situations. (SCult)	.10	-.17	**.60**	-.16	.26	-.04	-.05	.34
Punishment decreases a person's behavior. (Beh)	.13	-.01	**.78**	.02	.25	.02	.03	-.18
Knowledge is shared by those participating in an activity. (SCult)	.04	-.06	-.35	**.66**	.04	.06	.17	.31
Individuals can change the environment around them. (SCT)	.06	.18	.20	**.77**	.04	.05	.25	-.09
Individuals learn primarily through new experiences they have. (CC)	-.17	.03	.43	**.51**	-.15	-.12	-.16	.35
Young children have difficulty understanding other people's thoughts. (CC)	.12	.02	.26	.19	**.79**	-.06	-.01	-.02
In order for information to be processed it must be perceived and attended to. (IP)	-.26	.08	.01	-.01	**.61**	.49	.07	.17

Young children can understand the thoughts of others. (SocCon)	.27	.04	.04	.16	**-.81**	.17	-.05	-.20
Learning occurs through a process of equilibration. (CC)	.23	.20	-.08	.48	-.08	**.64**	-.13	-.05
New knowledge is assimilated or accommodated by an individual. (CC)	.37	-.07	-.03	.08	.08	**.73**	.11	-.04
Scientific concepts must be explicitly taught. (SocCon)	-.11	.06	.28	-.18	-.22	**.70**	.15	.23
Learning occurs when knowledge moves through different memory stores. (IP)	.00	.07	.33	.09	.24	.12	**.77**	-.03
Individuals can learn by watching others around them. (SCT)	.32	.34	-.22	.35	-.10	.09	**.61**	-.09
Beliefs about one's ability to complete a task can affect their behavior. (SCT)	.34	.42	-.19	.11	-.22	-.04	**.57**	.09
Individuals' behavior can be shaped solely by the environment. (Beh)	.04	.17	.11	.06	.21	.09	-.10	**.81**
Individuals learn primarily through social interactions they have. (SocCon)	.38	-.23	-.04	.30	.04	.16	.31	**.53**

For knowledge, there was a slight shift toward the conception that knowledge was something acquired from sources and experience across the semester, although there certainly were numerous examples of PSTs that were consistent across the course of the semester with their definitions: knowledge acquired from sources (n=34), the information you can explain to yourself and teach (n= 2), and real-life application (n=4). Table 4 shows these shifts from pre- to post-test.

Pre-service teachers' perceptions of knowledge and beliefs about learning

An exploratory factor analysis of PSTs' perceptions about their beliefs and knowledge of learning revealed that they were not necessarily organized around each of the formal theories either at the pretest or at the posttest. Factor loadings revealed that statements about learning loaded on between seven to eight factors with each factor containing statements mostly from disparate theoretical points of view for pretest beliefs (Table 5), pretest knowledge (Table 6), posttest beliefs (Table 7), and posttest knowledge (Table 8). There was only a slight shift toward more congruence in their perceptions of posttest knowledge about learning, with the first factor explaining a higher percentage of the total variance (33%) in those items.

Table 6. Pre-service teachers' perceptions of their knowledge about learning at the pretest

	Component							
Items about Learning	1	2	3	4	5	6	7	8
Beliefs about one's ability to complete a task can affect their behavior. (SCT)	**.65**	.17	.49	.03	.22	.06	.07	-.05
Knowledge can be divided up into declarative, procedural, and conditional knowledge. (IP)	**.78**	-.07	.17	-.06	.08	-.05	.06	.27
Stimuli can be associated with one another to influence behavior. (Beh)	**.51**	.06	.15	.08	.16	-.67	-.10	.11
Individuals learn primarily through social interactions they have. (SocCon)	**.76**	.30	.14	.22	.01	.05	.12	-.15
Cultural tools vary from culture to culture. (SCult)	.11	**.78**	.15	.12	.12	.06	.17	.32
Individuals can learn by watching others around them. (SCT)	.03	**.81**	-.09	.15	.02	.03	-.09	-.04
Learning occurs when children are engaged in relevant cultural activities. (SCult)	.17	**.51**	.46	.25	.28	-.04	-.07	-.03
Both personal and environmental factors can shape behavior. (SCT)	.45	**.58**	.00	.19	.06	.28	.07	.06
Information is encoded more easily when it is associated with prior knowledge. (IP)	.17	.18	**.75**	-.14	.21	.18	.01	.07
Reinforcement increases a person's behavior. (Beh)	.10	-.07	**.85**	.05	-.08	-.08	.16	.06
Young children can understand the thoughts of others. (SocCon)	.28	-.12	**.55**	.48	.22	-.02	-.20	.23
Learning occurs through a process of equilibration. (CC)	.35	-.43	**.50**	.10	.43	.06	-.04	.13
Knowledge is shared by those participating in an activity. (SCult)	.22	.17	-.23	**.70**	.18	.30	-.24	-.13
Individuals can change the environment around them. (SCT)	-.10	.18	.08	**.82**	.06	-.05	.19	-.14
Learning occurs only in authentic situations. (SCult)	.11	-.29	.04	**.46**	.05	.28	.16	.41

Individuals learn primarily through new experiences they have. (CC)	.11	.26	.08	**.72**	-.02	.18	.17	.17
New knowledge is assimilated or accommodated by an individual. (CC)	-.15	-.19	.17	.05	**.76**	-.34	.02	.23
Scientific concepts must be explicitly taught. (SocCon)	.26	.30	.03	.00	**.60**	.02	.04	.16
In order for information to be processed it must be perceived and attended to. (IP)	.08	.16	.20	.23	**.55**	.36	.37	-.27
Learning consists of children incorporating social activities into their thoughts. (SocCon)	.26	.24	.09	.14	**.53**	.45	.01	.09
Individuals' behavior can be shaped solely by the environment. (Beh)	.10	.10	.13	.28	.01	**.82**	-.07	.09
Young children have difficulty understanding other people's thoughts. (CC)	.35	.06	-.21	.11	.31	.03	**.61**	.31
Punishment decreases a person's behavior. (Beh)	.02	-.01	.15	.10	-.02	-.02	**.89**	.03
Learning occurs when knowledge moves through different memory stores. (IP)	.07	.23	.15	-.05	.21	-.01	.09	**.76**

However, when examining these items by theory (means of each of the four items per theory), some interesting trends emerged. PSTs' beliefs and knowledge were significantly different across these theories at both pre and post-test (Table 9). Follow-up analyses also indicated significant differences from pre to post-test for some of the theoretical views (Figure 1). Overall, there was little shift in PSTs' beliefs throughout the course of the semester, with the only significant change being an increase in their beliefs about statements related to cognitive constructivism (F=9.95, p<.01, $p\eta^2$=.26). Perceptions of knowledge, however, significantly changed more frequently with increases for behaviorism (F=6.06, p=.020, $p\eta^2$=.18), cognitive constructivism (F=16.85, p<.01, $p\eta^2$=.38), and information processing (F=10.78, p<.01, $p\eta^2$=.28).

Table 7. Pre-service teachers' perceptions of their beliefs about learning at posttest

	Component							
Items about Learning	1	2	3	4	5	6	7	8
Cultural tools vary from culture to culture. (SCult)	**.63**	.28	.34	-.12	.28	-.09	.13	.17
Individuals can learn by watching others around them. (SCT)	**.85**	.17	.15	.06	.17	.04	-.08	.00
Information is encoded more easily when it is associated with prior knowledge. (IP)	**.85**	.04	.06	.08	.14	.01	-.10	-.03
Beliefs about one's ability to complete a task can affect their behavior. (SCT)	**.68**	.10	.12	.37	.19	.09	-.03	.09
Individuals can change the environment around them. (SCT)	**.70**	.12	.11	.24	-.06	-.12	.39	.11
In order for information to be processed it must be perceived and attended to. (IP)	.18	**.72**	.06	.17	.10	.31	.01	-.31
Reinforcement increases a person's behavior. (Beh)	.05	**.79**	.06	.21	-.18	-.24	.17	-.06
New knowledge is assimilated or accommodated by an individual. (CC)	.29	**.64**	.18	-.06	.18	-.04	-.39	-.01
Scientific concepts must be explicitly taught. (SocCon)	-.14	**.60**	-.15	.33	.23	-.05	-.02	.48
Learning occurs when knowledge moves through different memory stores. (IP)	.40	**.56**	.14	-.34	.37	.13	.03	.31
Both personal and environmental factors can shape behavior. (SCT)	.48	**.62**	-.05	-.12	-.03	.31	-.30	.14
Knowledge can be divided up into declarative, procedural, and conditional knowledge. (IP)	.01	-.03	**.83**	-.05	.12	.26	.06	.07
Stimuli can be associated with one another to influence behavior. (Beh)	.36	.09	**.75**	.25	.13	.14	.10	.01
Knowledge is shared by those participating in an activity. (SCult)	.30	.18	**.64**	.44	.14	-.09	.09	.13
Individuals learn primarily through social interactions they have. (SocCon)	.16	.22	.10	**.79**	.05	.10	.09	-.13
Individuals learn primarily through new experiences they have. (CC)	.24	-.09	.25	**.67**	.22	.34	-.11	.25
Learning occurs when children are engaged in relevant cultural activities. (SCult)	.24	-.07	.07	.18	**.74**	-.16	.04	-.10

Learning consists of children incorporating social activities into their thoughts. (SocCon)	.19	.16	.23	.04	**.84**	.09	-.03	.05
Individuals' behavior can be shaped solely by the environment. (Beh)	.17	-.13	.18	.12	-.22	**.74**	.17	.09
Learning occurs only in authentic situations. (SCult)	-.17	.16	.13	.11	.11	**.84**	.08	-.08
Young children have difficulty understanding other people's thoughts. (CC)	.26	.21	-.15	.19	-.03	-.06	**-.72**	.08
Young children can understand the thoughts of others. (SocCon)	.16	.08	.05	.13	.00	.12	**.73**	-.02
Learning occurs through a process of equilibration. (CC)	.32	-.01	-.09	.08	.31	.18	.38	**.59**
Punishment decreases a person's behavior. (Beh)	.05	-.07	.26	-.06	-.21	-.06	-.21	**.72**

Interrelations of perceptions of learning and instruction

The qualitative component of this study utilized an open-ended question from the survey to see to what degree their beliefs about learning and instruction framed participants' beliefs about effective instruction. The participants' beliefs about effective instruction fell in one or more of the following categories, congruent with Ball et al.'s (2008) framework: knowledge of the subject matter, knowledge of pedagogy, knowledge of students, knowledge of classroom management, and teacher affect. These categories informed our initial coding. At a quick glance, all these behaviors are included in our five large categories.

Knowledge of the subject matter

The participants deemed essential for teachers to "know what they teach" (Shulman 1986). A knowledgeable teacher keeps "up to date on new material and technology" (PST26), and is able to prioritize information to teach the most meaningful and relevant material. In addition, the teacher needs to be able to "relate the information to the real world so the students see a purpose in it" (PST29). Another participant addressed the need for teachers to have prior knowledge about the topic being taught, "so that questions about the topic can be answered correctly" (PST38).

Table 8. Pre-service teachers' perceptions of their knowledge about learning at posttest

	Component						
Items about Learning	1	2	3	4	5	6	7
Individuals learn primarily through new experiences they have. (CC)	**.66**	.57	.04	.05	-.01	.12	-.07
Cultural tools vary from culture to culture. (SCult)	**.78**	-.12	.15	-.14	-.02	.04	.19
Individuals can learn by watching others around them. (SCT)	**.61**	.13	.15	.27	.33	.20	.23
Information is encoded more easily when it is associated with prior knowledge. (IP)	**.78**	.02	.07	.35	.00	.29	.03
Learning occurs when children are engaged in relevant cultural activities. (SCult)	**.80**	.14	.08	.00	.23	.03	-.15
Beliefs about one's ability to complete a task can affect their behavior. (SCT)	**.59**	.28	-.09	.39	.25	.18	.28
Stimuli can be associated with one another to influence behavior. (Beh)	**.68**	.19	.04	.11	.27	.08	.40
Individuals learn primarily through social interactions they have. (SocCon)	**.45**	.13	.50	.41	-.23	.25	-.10
Knowledge is shared by those participating in an activity. (SCult)	**.85**	.24	.02	-.04	.09	-.02	.00
Individuals can change the environment around them. (SCT)	**.49**	-.12	.42	.41	.04	.10	.27
Individuals' behavior can be shaped solely by the environment. (Beh)	.27	**.67**	.22	.12	-.20	.27	.20
Both personal and environmental factors can shape behavior. (SCT)	.16	**.43**	.41	-.18	.37	.27	.04
Learning occurs only in authentic situations. (SCult)	.08	**.78**	.00	.18	.10	-.11	.15
Reinforcement increases a person's behavior. (Beh)	.08	-.14	**.66**	.08	.13	-.14	.32
In order for information to be processed it must be perceived and attended to. (IP)	.00	.24	**.80**	.05	.08	-.03	.00
Learning occurs through a process of equilibration. (CC)	.22	.27	.12	**.79**	-.10	-.19	.11
Scientific concepts must be explicitly taught. (SocCon)	-.19	.02	.01	**.73**	.37	.32	.09
Learning occurs when knowledge moves through different memory stores. (IP)	.16	.00	.18	.04	**.79**	-.03	.16
New knowledge is assimilated or accommodated by an individual. (CC)	.42	-.29	.32	-.06	**.46**	.35	-.09

Learning consists of children incorporating social activities into their thoughts. (SocCon)	.54	.11	-.18	.24	**.62**	.06	-.13
Young children have difficulty understanding other people's thoughts. (CC)	.13	.12	.11	-.03	.14	**.77**	-.11
Punishment decreases a person's behavior. (Beh)	.16	-.06	-.32	.17	-.13	**.71**	.18
Knowledge can be divided up into declarative, procedural, and conditional knowledge. (IP)	.56	.11	-.06	-.01	.19	.30	**.58**
Young children can understand the thoughts of others. (SocCon)	.01	.23	.23	.15	.01	-.09	**.74**

Knowledge of pedagogy

Most of the participants deemed essential the teacher's ability to teach in a way students understand, using a variety of instructional strategies: "Teachers should have effective teaching skills to help the students understand what they are taught, rather than just a lecture-based teaching" (PST25). The participants discussed the significance for teachers to engage students in fun and unique lessons, while at the same time challenging them. Participant PST41 reflected: It is important to address each student's learning needs and build off of prior knowledge and experiences when creating lesson plan assignments and projects. Lesson plans and assignments should engage all students. Additionally, an effective teacher engages their students in multiple practice opportunities and provides them with prompt and constructive feedback: "when grading or asking questions, giving positive feedback or praising a student can help boost their enthusiasm on the topic" (PST48), while PST26 suggested: Feedback on students' work will only benefit each child. Just writing 'good job' on their paper will not be as effective as talking with the students and telling them in what areas they are doing great and where they may need some improvement. Other participants mentioned the significance of effective communication in teaching. PST29 said: "To be an effective teacher one must know how to communicate with their students on a level that they can comprehend. Without communication, the students will be lost and the teacher will lose the focus on the students as well," while PST28 noted: "Teachers should have the ability to communicate effectively with students: otherwise, they will not understand what is going on and be less likely to both engage and be interested in learning."

Table 9. The results of ANOVA about beliefs and knowledge of different learning theories from pre- to post-test

Variable	Sums of Squares	df	*F*	*p*	Effect Size ($p\eta^2$)
Pretest Beliefs	32319.37	5	36.57	<.01	.41
Pretest Knowledge	31109.31	5	32.87	<.01	.39
Posttest Beliefs	22474.19	5	34.01	<.01	.45
Posttest Knowledge	24713.51	5	41.87	<.01	.51

Note. Each repeated measure analysis met the assumptions for sphericity.

Knowledge of students

Knowing one's students means knowing who they are as learners and individuals both inside and outside your classroom. Participants considered effective teachers those who understood their students' different learning styles, and planned for differentiation and accommodations: "Planning for accommodations, abilities, needs and wants in a lesson", stated PST35, while PST57 commented that in order to be an effective teacher, one needs to "understand your students' needs and understand that they are individually different and it is important to meet their needs." Moreover, an effective teacher understands their students' cultural backgrounds. For example, PST34 commented that an effective teacher understands "the amount of diversity in the classrooms and being able to adjust to those needs in order to make everyone feel comfortable learning," while PST35 thought that an effective teacher can teach "multiple types of learners, as well as exceptional students and English language learners." Modeling an understanding of diverse cultures was also deemed significant: "Being culturally aware when teaching so all types of students can try to connect somehow to the lesson" (PST38), and "The more diverse the teacher, the more they can relate to the students and the students can put their trust and power or learn into that individual" (PST42). Furthermore, PST41 commented: We live in a world that is culturally diverse; so, it is important to make sure that students are taught about multiple cultures in order to achieve a deeper appreciation and respect for those cultures. Also, integrating culture into the curriculum can help prepare students for the work field and a globally competitive world. A teacher who knows their students can relate to the students. PST34 urges teachers to keep an open mind

to be able to relate to the students: "it's easy to forget what it's like to be a student after so long but being able to connect to the struggle of a student is another important feature." Moreover, a teacher who knows their students holds their students to high standards: "having high expectations of the children will help the teacher to not baby them and give them the knowledge and skill based on their grade level or higher" (PST48).

Knowledge of classroom management

An effective teacher is an effective classroom manager. PST42 reflected on the need for a safe, welcoming environment, where students can feel they belong, and "where students can speak their mind without fear of ridicule and teasing," while PST45 commented: "A safe learning environment needs to be in place. Children need to feel comfortable in the space where they're learning and they need to feel like it's ok to make mistakes." Another characteristic of an effective environment is having organizational skills: "this comes in handy in regards to having all your paperwork in order on your desk" (PST29), being consistent and following through, having set routines, and providing reinforcements.

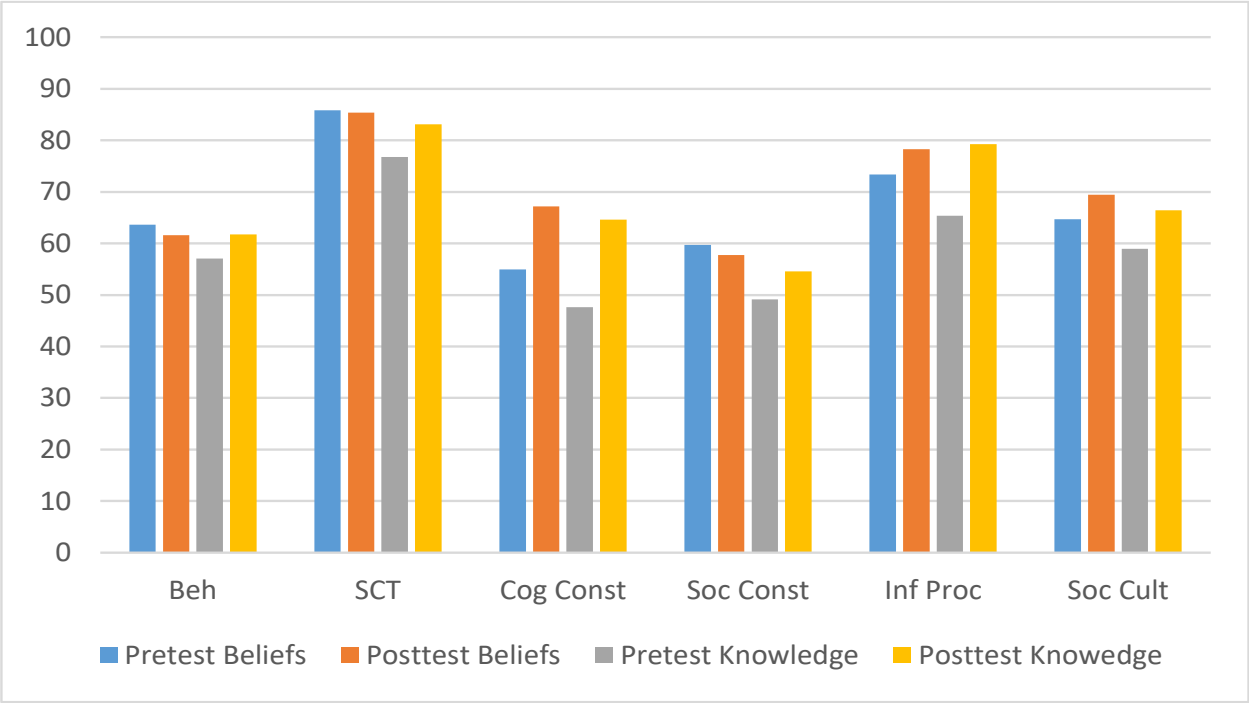

Figure 1. Changes in pre-service teachers' perceptions of their beliefs and knowledge about learning from pre- to post-test. *Note.* a denotes $p < .01$; b denotes $p < .05$

On the other hand, PST53 commented on the significance of time management: I think that time management is very important in the classroom. Students need to understand that tasks should be done in specific times so that they learn the value of time. Similarly, teachers need to be able to complete all tasks with their students to make sure the students are successful in the work they are completing. An effective teacher motivates their students. PST38 argued: "A modern-day teacher must have a strong motivation to help students. There are many things today that will trouble a teacher and make him/her feel hopeless, but a teacher must never lose their motivation to advocate for their students."

Teacher affect

Teacher affect has a significant impact on student learning. The participants reflected on the many qualities effective teachers should embody. Among the most frequently mentioned are patience, trustworthiness, reliability, respect, credibility, kindness, compassion, availability, creativity, empathy, and a strong belief in the students. The essence of all these attributes can be summed up in one word: care. An effective teacher cares about their students: "A teacher must always care for the students' health and wellness and make it a first priority when working with her students" (PST38), and "there can be few adult role models in a student's life, and it's your job to be one no matter what. Showing the students that you care should motivate them to go above and beyond what they dreamed they could do," stated PST28. A caring teacher is committed to the students and their learning, "Teachers need to be

committed to helping their students learn and thrive in the classroom" (PST26), and they are fair: "Always interact with every student and do not have a favorite student" (PST48).

Moreover, a caring teacher adapts to the needs of their students: "You may want to teach the students one way, but realize another way is more relatable, so you do it that way." (PST42). The sense of humor was also deemed an essential attribute of an effective teacher: "I think that the teacher should use humor to make a personal connection with the students so they feel comfortable with you" (PST29), while other participants reflected on the significance of having a positive attitude: "Teachers must create a positive learning environment to keep children excited and ready to learn and play in the classroom! No one wants a negative teacher" (PST45), and PST56 said: "no matter the situation to always have a smile so the students won't lose hope." The participants also associated teacher affect with the teacher's willingness to self-improve. PST45 reflected: Teachers must be open to learning new things all the time, from other teachers AND from their students. They must also be willing to look at their past lessons and reflect on what works and what didn't work and build on that knowledge. Similarly, PST38 stated: "self-improvement is important for a teacher, because if a teacher does not learn and grow each year from their students and peers, then eventually they would no longer be teaching relevant topics."

Mixing the quantitative and qualitative data using case studies: changes in pre/post teaching beliefs and the influences on perceptions of beliefs and knowledge

In total, there were only six cases where there was a qualitative shift in PSTs' conceptions of effective instruction and the possible influence of the change in their conceptions of belief and knowledge, as well as their perceptions of their beliefs and knowledge about learning. For example, the conceptions of effective instruction shifted for PST28 from rote memorization at the pretest to more experiential types of learning at the posttest. This was accompanied by a concomitant change in his beliefs about learning, with decreases in beliefs about statements related to behaviorism, and large increases in statements related to beliefs about cognitive and social constructivism. There were also large increases in perceptions of knowledge related to statements about both cognitive and social constructivism as well. Thus, in his case, there appears to be a close relation between beliefs and knowledge about learning and how this translates into PSTs' conceptions of effective teaching.

For participants 25 and 35, there was a notable shift from pre- to post-beliefs, with the post-beliefs including patience and an understanding that students learn in many different ways as effective characteristics, but to these, pedagogical content knowledge was added (i.e. the teacher creates lessons that have a real-life application, and implements lessons keeping in mind student diversity). This shift in post-beliefs about instruction may be due to the semester's readings and discussions about the teacher's ability to use diverse instructional strategies to meet their students' needs. The quantitative data revealed no change in these participants' pre and post-surveys, with knowledge and beliefs having both distinct and overlapping parts.

Similarly, for PST26, the post-beliefs on instruction became more refined and specific. While the pre-beliefs showed an understanding of the candidate's need to know their students, to know how to write a lesson plan, and be able to manage their classroom, the post-reflection showed the candidate's understanding of the need for the teacher to engage their students in meaningful learning and to provide them with specific feedback in a welcoming classroom setting. The quantitative data revealed a change from the view that knowledge is subsumed by beliefs to neither knowledge nor beliefs subsume each other but that they are completely intertwined.

For PST47, there was a notable shift from pre- to the post- beliefs of teaching, as the post-beliefs emphasized the teacher's understanding of the students' culture (i.e. an understanding of the students' linguistic and SES backgrounds). Moreover, the participant elaborated on what proper classroom management may mean (pre-belief), discussing the need in the post-reflection for the teachers to provide positive, yet varied reinforcement for the students. This participant reflected on information covered in both classes, showing an understanding of the connection between educational psychology theories, instruction, and classroom management. The quantitative data reveal that PST47 changed from knowledge being subsumed by beliefs to beliefs being subsumed by knowledge.

The post-beliefs of PST41 reflect a deeper understanding of pedagogical content knowledge, as the candidate reflected on the benefits of using a variety of instructional strategies in the class. The participant described four such strategies, and while they still refer to some of the essential attributes they mentioned in the pre-beliefs (constructivism, scaffolding), the post-reflection showed an understanding of how educational theories played into

classroom instruction. The quantitative data revealed no change in that pre and post-surveys, knowledge and beliefs both having distinct and overlapping parts for these participants. However, there were many cases where changes in PSTs' beliefs and knowledge about learning led to very little change in their conceptions of effective teaching. This may be due, on one hand, to the fact that some of the PSTs were not enrolled in a field class while taking the classes with the two researchers, and what they learned in these classes continued to stay at a theoretical level, absent a direct exposure to what effective teaching might look like in the field. On the other hand, this may be due to the PSTs witnessing an incongruence between faculty beliefs and principles of effective teaching in some of the classes they were enrolled in.

Discussion

The findings related to PSTs' epistemic beliefs and beliefs about teaching and learning fill an important void in the research literature, with calls for more research on the development of teachers' beliefs about learning and teaching (Parkinson & Maggioni, 2014). With regard to this, these findings indicate that even over the course of a semester, these beliefs are relatively dynamic, particularly in terms about perceptions of knowledge of learning and less so in terms of perceptions of beliefs about learning. Secondly, the case studies in particular offer a qualitative look at the relationship between PSTs' beliefs and knowledge about learning and their conceptions of effective teaching, as Vermunt and colleagues (1999; 2014) have called for.

These findings can also inform practice in teacher education programs. Surprisingly, there was less change in PSTs' beliefs about learning, which is important since these beliefs may be much more likely to influence their decision making as both a pre- and in-service teacher (Cornett et al., 1990). However, there may be positive benefits to the inclusion of empirical studies in these courses as we did see a shift in definitions of knowledge with PSTs indicating that evidence was required before something could be considered knowledge at posttest more so than at pretest. Additionally, this focus on beliefs about learning should include more effort spent on discussing PSTs' epistemic beliefs, as we found relations between their epistemic beliefs, perceptions about teaching and learning, and conceptions of effective teaching in the case studies. Thus, practically speaking, we believe this evidence supports the idea that teacher preparation programs should include conceptual frameworks that take into account teachers' beliefs. Rather than teaching PSTs about what works, there needs to be a better articulation in teacher preparation programs on the congruence or incongruence of faculty beliefs and this may translate to a comprehensive teaching and learning framework for the program as a whole.

The above findings warrant the following implications for research: firstly, researchers conducting future studies should follow the PSTs beyond one semester. Longitudinal studies would enable the researchers to identify any changes that might occur in the PSTs' epistemological beliefs as a result of future classes and fieldwork. Secondly, using different methodological tools (field observations) may enable researchers to capture the alignment between PST's beliefs and knowledge about instruction and the way they conduct classroom instruction. Observation data collected during the PSTs' internship program, and/or their first year of teaching might reveal the interrelationship between the PSTs' knowledge of learning and what they perceive to be principles of effective instruction. Thirdly, there needs to be a more direct articulation between the two levels – faculty and PSTs, that would allow researchers to find how much of the change could be attributable to faculty. Ultimately, this means building a better theoretical model that articulates how faculty beliefs and knowledge may influence PSTs' beliefs and knowledge.

Compliance with Ethical Standards

Competing interests

The authors acknowledge no conflict of interest.

Ethical standards

All study procedures involving human participants followed institutional and/or national research committee ethical standards and the 1964 Helsinki declaration and its later amendments or comparable ethical standards

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Data availability statement

The data that support the findings of this study are available at reasonable request from the corresponding author.

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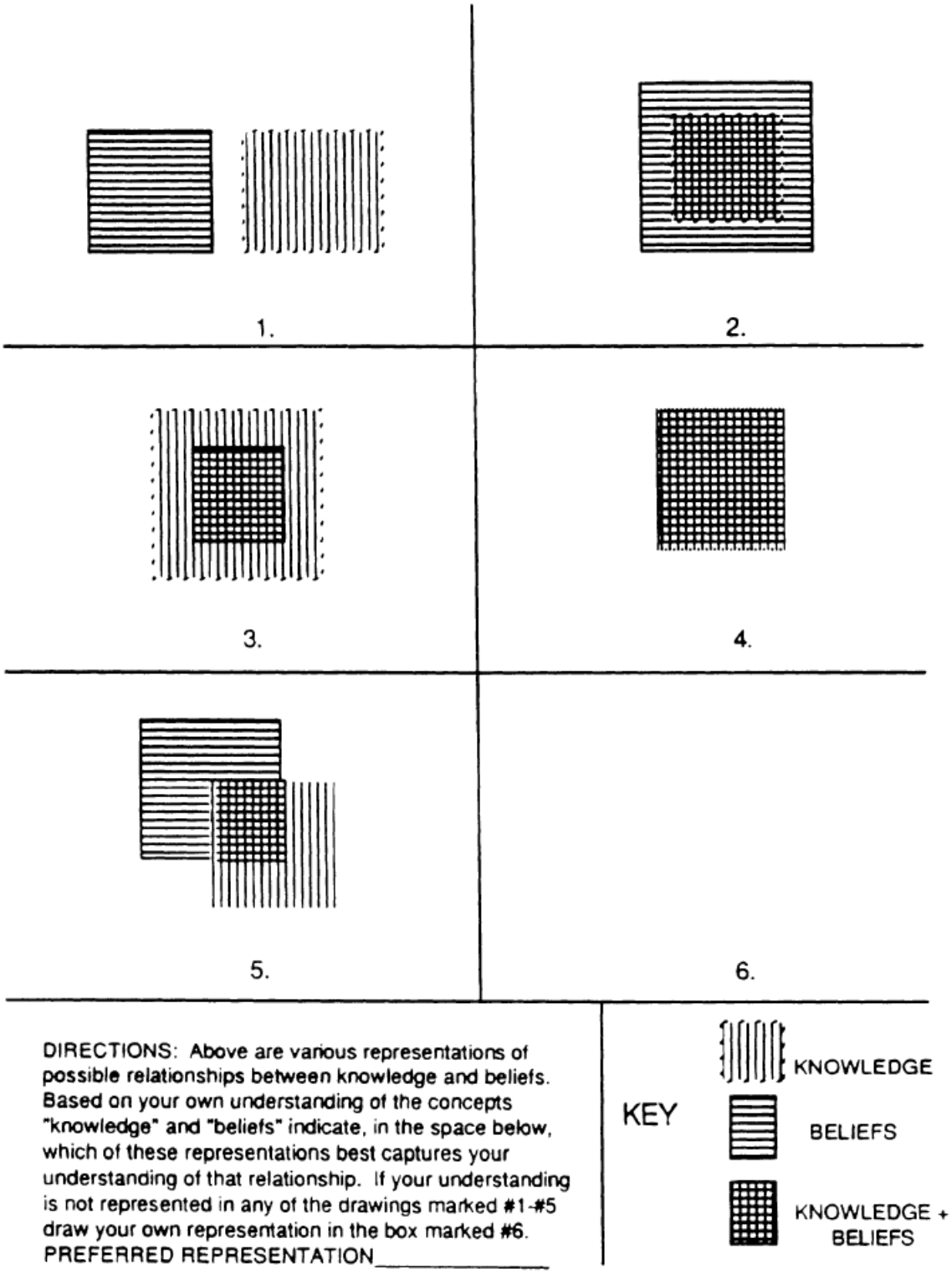
Appendix


1.
2.
3.
4.
5.
6.
DIRECTIONS: Above are various representations of possible relationships between knowledge and beliefs. Based on your own understanding of the concepts "knowledge" and "beliefs" indicate, in the space below, which of these representations best captures your understanding of that relationship. If your understanding is not represented in any of the drawings marked #1-#5 draw your own representation in the box marked #6.
PREFERRED REPRESENTATION_____
KEY
KNOWLEDGE
BELIEFS
KNOWLEDGE + BELIEFS

Open-ended Descriptions

1. Briefly describe what it means for something to be a *belief* for you.
2. Briefly describe what it means to something to be *knowledge* for you.

Teaching and Learning Beliefs and Knowledge (we should mix up the order for these)

*Each of these items would have two scales associated with it – one scale that ranges from "I **don't know** this" to "I **do know** this" and another scale that ranges from "I **don't believe** this" to "I **do believe** this".*

1. Reinforcement increases a student's behavior. (BEH)
2. Punishment decreases a student's behavior. (BEH)
3. Individuals' behavior can be shaped solely by the environment. (BEH)
4. Stimuli can be associated with one another to influence behavior. (BEH)
5. Learning occurs through a process of equilibration. (CC)
6. New knowedge is assimilated or accommodated by an individual. (CC)
7. Individuals learn primarily through new experiences they have. (CC)
8. Young children have difficulty understanding other people's thoughts. (CC)
9. Individuals learn primarily through social interactions they have. (SCon)
10. Learning consists of children incorporating social activities into their thoughts. (SCon)
11. Young children can understand the thoughts of others. (SCon)
12. Scientific concepts must be explicitly taught. (SCon)
13. Learning occurs when knowledge moves through different memory stores. (IPT)
14. In order for information to be processed it must be perceived and attended to. (IPT)
15. Information is encoded more easily when it is associated with prior knowledge. (IPT)
16. Knowledge can be divided up into declarative, procedural, and conditional knowledge. (IPT)
17. Learning occurs only in a specific context. (SCult)
18. Learning occurs when children are engaged in relevant cultural activities. (SCult)
19. Cultural tools vary from culture to culture. (SCult)
20. Knowledge is shared by those participating in an activity. (SCult)
21. Both personal and environmental factors can shape behavior. (SCT)
22. Individuals can change the environment around them. (SCT)
23. Individuals can learn by watching others around them. (SCT)
24. Beliefs about one's ability to complete a task can affect their behavior. (SCT)

Open-ended Teaching Question

What are the five most important principles of effective teaching to you? Please list and briefly describe each.