

Using microteaching to improve preservice elementary teachers' physical science content knowledge

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Abstract

This study examined the impact of microteaching experiences of preservice elementary teachers enrolled in a science teaching methods course. The microteaching lessons targeted the physical science concepts represented in the Texas Educational Agency's exam for early childhood through sixth grade teacher certification. The results of this study demonstrate that targeting preservice elementary teachers' specific areas of weakness in content through microteaching, feedback, and reflection can have a positive impact on the science subject teacher certification exam passing rate. Additionally, this type of intervention provides preservice teacher programs with another technique to improve science content understanding.

Keywords: Physical science, elementary, preservice teachers, certification, content knowledge

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Introduction

Over the past decade and in response to national policy changes, teacher preparation programs have increasingly focused on the importance of elementary teacher content knowledge as a key variable associated with the improvement of student achievement (Darling-Hammond, 1999; Hill, Rowan, & Ball, 2005; National Commission on Teaching America's Future [NCTAF], 1996; Next Generation Science Standards, 2013). In the US, a wave of standardization and accountability has led to the development of state content standards which are linked to state assessment systems used to determine adequate yearly progress of students in reading and mathematics. Concurrent with accountability systems for students, states have enacted content standards and state assessment systems for teachers (Council of Chief State School Officers, 2004; Feistritzer, 2010) Since the implementation of *No Child Left Behind legislation* (2002),

almost all states assess teacher content knowledge using state licensure examination scores, and many states require completion of specified content coursework as well (Feistritzer, 2010; National Science Teachers Association [NSTA], 2012). All states use teacher content testing as a state licensure requirement for a multiple subject credential (Angrist & Guryan, 2007; Goldhaber, 2007; Clotfelter, Ladd & Vigdor, 2006).

However, practices such as low set points for passing scores, unlimited test taking opportunities, and no requirement to pass each domain of the multiple subject credential do little to assure elementary teachers understand *all* the subjects they are required to teach. Taken together, a reliance on national and state policies regarding student testing, teacher testing, and use of multiple subject credentials, represent political practices that may compromise the development of scientific knowledge; and create a context in which coherent and coordinated science instruction is uncertain (Akerson & Flanigan, 2000; Neale, Smith & Johnson, 1990; Stoddart, Connell, Stofflett, & Peck, 1993).

Although there is disagreement concerning how much content knowledge is needed for effective teaching, there is general agreement that teachers must demonstrate acquisition of some content knowledge related to state, national, common core, Catholic school, or other education standards (Ferguson & Womack, 1993; Guyton & Farokhi, 1987; Neale, Smith, & Johnson, 1990; Pfundt & Duit, 2000; Stoddart, Connell, Stofflett, & Peck, 1993). Researchers agree that content knowledge is, “the first necessary, but insufficient, condition” for effective teaching (Garnett & Tobin, 1988) and that content knowledge forms the foundation for pedagogical content knowledge (PCK) which is used to make concepts accessible to students (Shulman, 1986). With this fundamental need for teacher content knowledge in mind, over the last decade, only a few studies have addressed common scientific understandings held by elementary preservice science teachers (Akgün, 2009; Antink-Meyer and Meyer, 2016; Calik, Ayas, & Coll, 2007; Gomez-Zweip, 2008; Long, 2019; Moodley and Gaigher, 2019; Namdar 2018; Othman, Treagust, & Chandrasegaran, 2008; Potvin, and Cyr, 2017).

Research Question

This study was framed by the following research question:

How does lesson plan design instruction and student microteaching of physical science concepts contribute to PSETs content knowledge?

We investigated the effectiveness of an instructional intervention in improving the physical science content knowledge of preservice elementary teachers (PSETs) at a large public university in Texas. The study examined the TEXES EC-6 Core Subjects (science) scores for 408 PSETs.

Literature Review

Content Knowledge and Pedagogical Content Knowledge

The federal legislation that replaced the No Child Left Behind Act, the Every Student Succeeds Act [ESSA], 2015), went into effect around the country with the start of the 2017-2018 school year, and has implications for teacher education and certification programs (ESSA, 2015). While ESSA legislation lifted the highly qualified teacher mandate, the new law requires that state agencies continue to apply certification requirements and standards that are already in place if they are to receive Title I funding.

In the past several years, various national educational agencies have called on licensing entities in states to raise their standards for teacher certification and include assessments and other measures that provide evidence of teacher content that aligns with the learning standards their students will be required to master (Council of Chief State School Officers, 2012; Hoss & Eberle, 2015). These calls for increased rigor for entry into the classroom have been answered by state-level changes; changes that require teacher education programs to persist in their efforts to improve existing approaches for preparing preservice Elementary teachers (PSETs) to meet certification requirements that foster success in the classroom (Anggoro, 2017; Angrist & Guryan, 2006; Koc & Yager, 2016). To help PSETs meet these changing teacher certification standards and pass the assessments that are embedded in this process, teacher education instruction must ensure that PSETs have a deep understanding of the content for which they will be assessed.

A deep understanding of content does more than ensure passing of state required content assessments, it provides newly minted teachers a foundation for building teaching skills as they grow in their profession. Shulman (1986) discussed the different types of knowledge that form the deep understanding that good teachers need. Shulman (1986) asserts that content knowledge is the supportive platform upon which teaching or pedagogical content knowledge (PCK) is built. Shulman's statement, "Pedagogical content knowledge also includes an understanding of what makes learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons" (p. 9) makes clear that the teacher must be able to recognize and attend to the specific concepts within topics that present increased challenges to their students. Reinforcing the notion that content knowledge is a foundational component of PCK, Riggs and Enochs (1989) provided the tools needed to fully understand the interplay between types of teacher knowledge, teacher self-efficacy, and teacher classroom behaviour. There is little doubt as to the importance of ensuring that elementary science teachers acquire adequate content knowledge, and pedagogical content knowledge.

Together with content knowledge, the teacher must be able to correct misconceptions or place increased emphasis on supportive skills that may be lacking. In a large study of middle school physical science teachers and their students, researchers specifically examined questions that had "popular" wrong answers; these wrong answers would likely indicate the existence of widely held misconceptions regarding the content needed to answer correctly (Sadler, Sonnert, Coyle, Cook-Smith, & Miller, 2013, p. 1021). The findings by Sadler indicate that students of teachers who recognized misconceptions fared much better than the students whose teachers knew the correct answer, but not the associated misconception. This study emphasizes that pedagogical content knowledge is more than knowing the content, but rather PCK is knowing the best ways to navigate that content while remaining cognizant of the specific instructional challenges that present themselves as the teaching process unfolds. It is not surprising that PCK has been shown to be a better predictor of who will be able to teach well compared to using teacher content knowledge alone (Darling-Hammond, 2000; Guyton & Farokhi, 1987).

Teacher preparation programs are well positioned to instil both content knowledge and PCK. Multiple, researchers have proposed that teacher preparations programs must play a critical role in developing teachers who are able to effectively engage students in the classroom. (Carrier, 2013; Kelly, 2000; Parker & Heywood, 2000;

Veal & Allan, 2014). The development of teacher self-efficacy, grounded in Bandura's conceptions of mastery experiences, has been linked to teacher willingness to spend class time on specific subjects. Preservice teachers that possess sufficient content knowledge and who also have the opportunities to develop PCK built upon the supportive foundation of content knowledge will not avoid teaching subjects when they enter their own classrooms, but rather will be more likely to present lessons that are student-centered and inquiry-based (Appleton & Kindt, 2002; Bandura, 1993; Bleicher, 2006; Kazempour, 2013). These teachers will be confident enough in the own ability to allow lessons to veer outside what is planned and respond to student needs.

Physical Science Content Knowledge

Within the context of content knowledge and the important components of teacher preparation that are connected to it, science teaching at the elementary level has often been an area of concern as studies have shown that elementary teachers have insufficient science content knowledge that leads to lowered teaching self-efficacy and a reluctance to teach science (Anggoro, 2017; Appleton, 2008; Appleton & Kindt, 2002; Koc & Yager, 2016; Parker & Heywood, 2000). Within the field of science, physical science content has consistently proven difficult for preservice elementary teachers to master, which creates two problems for teacher education programs: a hampered ability to develop physical science specific pedagogical content knowledge and difficulty passing the science subject certification test. The difficulty in mastering physical science content knowledge represents a persistent gap in science content knowledge that is not limited to PSETs in any one state or country and has persisted despite years of attention (Akgun, 2009; Anggoro, 2017; Anggoro, Widodo, & Suhandi, 2017; Dawkins, Dickerson, & Butler, 2003; Ginns & Watters, 1995; Koc & Yager, 2016; Papadouris, Hadigeorgiou, & Constantinou, 2014; Potvin & Cyr, 2017; Stein, Larrabee, & Barman, 2008; Yilmaz-Tunun, 2007). Deep understanding of physical science content requires that students have a firm grasp of its concepts, the relationships between the concepts, and the procedures and skills needed to solve specific problems within the content (Bleicher, 2006).

One obstacle to understanding physical science has been identified as stemming from the intersection of personal experience and scientific concepts. Many concepts central to physical science content, such as Newton's Laws of Motion, are often approached by learners of all ages with misconceptions that run counter to scientific ideas, but are supported by the learners' personal experiences; a fact that makes these topics particularly difficult to comprehend (Anggoro, 2017; Koc & Yager, 2016; Parker & Heywood, 2000; Potvin & Cyr, 2017). For example, the idea that an applied force is not needed to maintain motion seems intrinsically counter-intuitive because less obvious forces like friction are not accounted for in many, if not most, students' initial conceptions of kinematics. Preservice elementary teachers who carry their misconceptions with them to the classroom are likely to report feeling less comfortable teaching science and are more likely to rely heavily on teacher-centered instruction when delivering science lessons (Appleton, 2008; Santu, Maerten-Rivera, Bovis & Orend, 2014; Yilmaz-Tuzun, 2007). Another concept that proves troublesome for PSETs is buoyancy. Difficulties understanding buoyancy illustrates all the components for understanding science described by researchers (Bleicher, 2006; Potvin & Cyr, 2017). For example, understanding buoyancy requires the ability to make connections between the science concepts of mass, volume and density as well as an understanding of the correct mathematical equation necessary to determine what sinks and what floats and why.

Studies have also examined PSETs' understanding of concepts such as forces and motion, gravity, physical and chemical changes, density, buoyancy, energy transformations and conservation (Akgun, 2009; Anggoro, 2017; Anggoro, Widodo, & Suhandi, 2017; Dawkins, Dickerson, and Butler, 2003; Papadouris, Hadijeorgiou, & Constantinou, 2014; Potvin & Cyr, 2017; Stein, Larrabee and Barman, 2008; Trumper, 2003, 1997). These findings indicate that gaps in science content knowledge persist across all topics in science.

Two approaches to increasing physical content knowledge among preservice teachers are modified science-content courses and science teaching methods courses. At some universities, science-content courses have been modified by structuring the content delivery to more closely reflect the teaching practices required by K-12 teachers. These courses reflect an effort to move away from the lecture format that the majority of existing science content courses utilize with the hope that preservice teachers will achieve greater content mastery as well as improved teaching skills. Courses specifically designed for PSETs have been shown to positively impact preservice teachers' self-efficacy for teaching science, their view of science, and conceptual understanding of the content (Bergman & Morphew, 2015; Cervato & Kerton, 2017; Hrepic, et al, 2006; Korb, Sirola & Climack, 2005; Menon & Sadler, 2016; Trundle, Atwood & Christopher, 2007). Studies that looked at content courses designed specifically for elementary preservice majors that covered physics topics each reported significant increases in scores on personal teaching self-efficacy among students upon completion of the course (Bergman & Morphew, 2015; Menon & Sadler, 2016). Cervato and Kerton (2017) reported similar increases in students' personal science teaching efficacy scores among students who completed a geosciences course designed for preservice teachers. Menon and Sadler (2016) also reported increases in physics content knowledge.

One possible explanation for the success of these tailored science-content courses may lie in the fact that although preservice secondary science teachers are recognized to have more science content knowledge and more expertise level ideas about science when compared to PSETs, the latter have an easier time when it comes to changing their alternative conceptions about science (Kaya, 2014; Palmer, 2001; Potvin and Cyr, 2017). This malleability in beliefs about how science works may serve as an advantage when elementary education students receive instruction in areas where they are likely to hold alternative conceptions as they are less resistant to reshaping their ideas to reflect correct understanding.

While specially designed courses for PSETs have produced positive effects Long (2019), the courses mentioned here include few, if any, course components that target the direct development of pedagogical content knowledge. This may explain why some students who leave these science-content courses and enter their required science teaching methods courses still experience gaps in their content knowledge (Ginns & Watters, 1995; Koc & Yager, 2016; Korb, Sirola & Climack, 2005; Trundle, Atwood, & Christopher, 2007; Trumper, 1997; Velthuis, Fisser & Pieters, 2013). Findings like these bring us to the second approach to helping PSETs master physical science: the science methods course.

Elementary Science Methods Courses

Within the structure of teacher education programs, science teaching methods courses can be viewed as the final opportunity to help preservice teachers master physical

science content as these classes are generally taken at the end of the university training. PSETs often enter these courses with deficits in science conceptual understanding, most if not all, will have concerns about their ability to teach science and will require assistance matching their science content to pedagogical skill-set (Peterson, & Treagust, 2014).

During a science methods course, taught by an experienced science educator, a PSET will see this interplay between content and pedagogical content modelled and will practice pedagogical content knowledge for themselves. These courses should function to provide students with the opportunity to transform their content knowledge into pedagogical content knowledge (Nilsson, 2008). Alternative models, even within the context of science methods courses are required to address the varied needs of PSETs as they work towards both attaining the content and pedagogical knowledge they need to succeed (Kelly, 2000). Science methods courses utilize field experiences, content learning, and curriculum development activities to encourage the connection between content and teaching ability as the bridge between the PSETs preparation and their own elementary classroom.

Microteaching

Microteaching, a component of many of the science teaching methods courses that were included in the studies mentioned above, was the focus of the study in this paper. Developed in 1960's at Stanford University, the method of microteaching as a tool for teacher education, can include teaching elementary students or other preservice teachers with the intent of recording and directly examining the interactions that occur during the teaching phase or reflecting on observations made by others during the lesson (Allen, 1967). Cycles of teaching practice (such as microteaching) paired with reflective activities is an effective tool for addressing self-efficacy in science teaching and science content knowledge, including physical science content knowledge (Akerson, Pongsanon, Rogers, Carter, & Galindo, 2015; Gunning & Mensah, 2010; Hanuscin & Zangori, 2016; Marble, 2007; Nilsson, 2008; Parker & Heywood, 2013; Zembal-Saul, Blumenfeld, & Krajik, 2000).

Methods

Context

Currently, the standards accessed by the certification exam PSETs are required to pass is divided into six subject areas, one of which is science. The state's education law now limits test takers to five attempts to pass any of the six parts of the elementary educator examination, which includes pedagogy, language arts, math, science, social studies, and fine arts (Texas Education Code §21.048, House Bill 2205, 84th Texas Legislature, 2015). Each attempt to pass any of the six parts of the test counts as one of the five attempts. Data reported by the certification agency for the two years since the number of attempts was limited shows that the science subject test ranks fifth out of the six in passing rates (73% and 77% respectively) compared to the other tests (TEA, 2016, 2017). Closer examination of the test items on the shows the portion of the subject test that assesses the domains included in physical science give test takers the most trouble. Because the physical science domains of the certification exam had the lowest passing scores, the science education faculty restructured the science methods course around the physical science focused microteaching assignment detailed below.

Resources were provided to PSETs who failed the exam in the form of practice questions and study guides. The PSETs were also encouraged to contact appropriate faculty to assist in studying for their next attempt. Although these resources were

provided to the PSETs, their use was voluntary and no data is available on how the PSETs interact with the resources provided. These resources were available both before and after the change to the science methods instruction.

The study examined 477 attempts at the TEXES EC-6 Core Subjects Exam results for 408 PSETs. Normally the PSETs in the teacher preparation program sit for the certification exam before taking the science methods class. If a PSET fails the science portion of the test, they usually make a second attempt during or after the science methods course. In order to assess the effectiveness of the microteaching exercise, the study analysed the results of the second attempt. The authors obtained IRB approval in order to examine the test result data and report their findings.

Sample

This study examined the certification exam, passing rate and scaled scores for 408 elementary preservice teachers enrolled in a 15-week science methods course. This study included a subset of 48 candidates who failed the initial science core exam, and subsequently took the exam a second time. All participants were female. Eight participants were African American (17%); nineteen were Hispanic (40%); nineteen were White (40%); and two were Asian (4%). All participants completed a minimum of twelve hours of science coursework as part of the degree and took a conceptual physics course taught by College of Science faculty. In general, participants did not complete any formal coursework in chemistry. The sample included exams taken prior to the implementation of the microteaching intervention and exams taken after the microteaching assignment was put in place. The comparisons in the study were made between the pre and post intervention students.

Microteaching Intervention

To increase the passing rate for the certification exam, faculty implemented a microteaching project in all sections of the science methods course. In a fully enrolled section of 24 students, the class was exposed to 23 additional physical science concepts taught through a well-vetted 5E lesson along with the one they prepared and presented themselves.

In addition to the physical science lessons that are delivered within the class, the students were required to prepare two additional lesson plans to the same, rigorous standards; one in life science and one in Earth/space science. These additional lessons were not presented to the class. However, they also contribute to the PSET's science content knowledge and PCK.

The project began with the assignment of a physical science standard associated with the Texas Essential Knowledge and Skills (TEKS) (Texas Education Agency, n.d.) for each PSET. An example of the topics assigned for the microteaching sessions included, buoyancy, average speed, dissolving, and energy transformation and electrical circuits. The standards for fourth, fifth and sixth grade; the upper half of the elementary sequence, were used. This was done to ensure that the participants were exposed to the more in-depth standards and stronger rigor of the higher level TEKS. The PSET then constructed a draft 5E lesson plan. Every PSET within each section was assigned a separate physical science standard. Therefore, a methods section could have as many as 24 physical science standards. Specific instruction in crafting a 5E lesson plan was delivered in first several weeks of the course to facilitate creation of the draft lesson plan.

After submitting their drafts, the participants worked with the instructor in a one-on-one session where they refined their lesson ideas, corrected any misconceptions, and planned for any necessary supplies or equipment required for a successful lesson. Emphasis was placed delivery of constructivist-based, hands-on, minds-on activities for the Explore step. Upon completion of the final lesson plan, the PSETs performed a micro-teach and delivered the first three stages (Engage, Explore and Explain) of their 5E lesson plan during class, with the majority of the PSET's colleagues acting as a mock class. The lesson delivery was scrutinized by the instructor as well as a panel of peers selected from the class. Every PSET serves as teacher, student, and reviewer during the course of the methods class. In some cases, videos of the lessons provided additional reflection and analysis.

The 5E Instructional Model

The instructional intervention employed a sequence of related 5E lessons (Abell & Volkman, 2006). The 5E instructional model was originally devised over 25 years ago by Roger Bybee to teach elementary science and health and has been extensively adopted and modified by other teaching disciplines (Bybee, 2014). The 5E instructional model frames a lesson into five phases; Engage, Explore, Explain, Elaborate, and Evaluate. An excellent summary of the model is provided by Tanner (2010).

Results

Overall performance

The study examined the EC-6 Core Subjects test results for 408 elementary preservice teachers' test scores. The exam consists of five domains; English language arts and Reading (ELAR), mathematics, social studies, science, and Fine Arts, Health and physical Education. If a candidate fails one or more domains, they may retake the failed domains. PSETs are allowed five attempts to pass the exam. Our study focused solely on the science core exam, specifically competencies in physical science. Table 1 shows the overall results for the PSETs first attempt of the science certification test. Table 1 reports percentage of passing scores and mean scores for all candidates as well as each of five ethnic subgroups.

While 84% of the teaching candidates passed the science core exam on the first attempt, a third of African American candidates failed as did approximately 22% of Hispanic participants; compared to 12% of White participants. Combined, African American and Hispanic participants accounted for nearly a third of the teaching candidates taking the exam. This is consistent with increasing diversity at the university in this study and similar universities across the country (National Center for Education Statistics, n.d). The first attempt passing rate for African-American and Hispanic participants was 75% compared to 88% for White and Asian participants. Of the 65 participants who did not pass the science portion of the test, 48 (26.15%) took the test a second time within the study period. White participants were less likely to make a second attempt with approximately 39% not taking the test again compared to 16% of African American and Hispanic candidates.

Table 1

Initial Attempt TEXES EC-6 Core Subjects (Science)

	Overall	African American	Hispanic/Latino	White	Asian	Other
N	408	34	94	275	14	9

Percent passing	84.07	67.65	77.66	87.94	85.71	100
Mean Score (100-300)*	257.42	242.85	253.17	260.75	255.00	265.33

**Passing=240*

Table 2 reports the results of a second attempt to pass the Core Subjects EC-6 Science test. The percentage of passing scores and mean scores for all participants are reported by ethnic subgroups (Table 1) with the exception of the “other” group candidates who passed on the first attempt. The overall passing performance on the second attempt was 50%. A passing score is 240 or higher. The African American candidates passing rate of 25% somewhat mirrors the subgroup’s performance on the first attempt of the test. Means for all subgroups were also lower than 240 on the second attempt. Of the 24 participants who failed the on the second attempt at the test, 6 (25%) did not make a third attempt within the study period.

The second attempt is of special concern for three reasons. First, participants who fail the test on the second attempt are at a high risk of never passing the test. In this study, of the 24 participants who failed the test a second time, 18 (75%) attempted it a third time with 61% passing rate. Only three of the seven participants who failed the third attempt persisted and passed on a 4th or 5th attempt. The reasons for the drop off after failing the test more than once are unclear from this study, but it may mean that: (a) the participant decided to choose another career; (b) they were unable to afford the expense of the third exam; or (c) the participant lacked confidence that they could pass the exam on a subsequent. Secondly, an evaluation criteria for teacher preparation programs (TPP) includes the passing rate during the first two attempts. It therefore, behoves a TPP to ensure that the second attempt is successful. Thirdly, the passing rate for those who do attempt the exam for a third time was only 50%. Hence, success by the second attempt is critical for the participants and the TPP.

Table 2
Second Attempt TEXES Core Subjects EC-6 (Science)

	Overall	African American	Hispanic/Latino	White	Asian
N	48	8	19	19	2
Percent passing	50.00	25.00	63.16	47.34	50.00
Mean Score (100-300)*	233.29	222.25	232.79	238.37	234.00

**Passing=240*

Table 3 compares 28 pre-intervention, second-attempt TEXES scores to the 20 post-intervention TEXES scores. There was a dramatic increase in the passing rate, pre to post intervention, from 36% to 70%. A chi-square test of independence found that the increase was significant, $\chi^2(1, N = 47) = 6.53, p < .05$. The intervention appears to have been equally effective for all participants regardless of ethnicity. PSETs passing rate for White participants improved from 22% to 70%, and minority PSETs improved from 42% to 70%. Mean scores also saw remarkable increases from 226.14 to 244.95. An independent samples t-test revealed that the increase in mean scores was significant between the non-intervention PSETs, i.e. those who attempted the test prior to the implementation of the microteaching centered instruction ($M = 232.56, SD = 33.31$) and the intervention PSETs, who attempted the test after the post implementation of the microteaching project. ($M = 244.95, SD = 14.03$) conditions; $t(45) = 2.32, p = 0.025$. The Hedges’ g effect size of 0.69, which is a medium to large effect size (Cohen, 1988).

White participants' mean scaled scores improved from 232.56 to 243.60. Similarly, minority participants saw the mean scale score move from 221.94 to 245.20. It is interesting to note that the post intervention scores are roughly equitable between White and minority PSETs.

Table 3

Second Attempt TEXES Core Subjects EC-6 (Science) Pre/Post Intervention

Ethnicity	No intervention			With Intervention			Change	
	N	Mean	Pass %	N	Mean	Pass %	Mean	Pass %
Black	8	222.25	0.25	0	-	-	-	-
Hispanic	11	223.18	0.55	8	246.00	0.75	22.82	0.20
White	8	235.13	0.25	10	243.60	0.70	8.47	0.48
Asian	1	218.00	0.00	1	250.00	1.00	32.00	32.00
Total	28	225.36	0.36	19	244.00	0.70	18.80	0.34

Table 4 reports the results of paired samples t-tests comparing the first and second attempt scaled test scores for the non-intervention and intervention groups. Prior to the intervention, there was no significant change in test scores on the second attempt. After the intervention was implemented in the methods course, the increase in score from the first attempt to the second attempt was significant to $p = .001$. However, the effect size of 0.17 is small according to Cohen (1988).

Table 4

Increase in scaled test scores from first to second attempt.

	Mean	SD	N	95% CI for Mean Difference	t	df
No Intervention	5.50	35.21	28	-8.15, 19.15	.83	27
Intervention	15.37	16.37	19	7.55, 23.19	4.13*	18

* $p < .001$

Discussion

Content selection

The teacher preparation program in the study, like many other teacher preparation programs, has few opportunities to address gaps in PSETs' science content knowledge. In the case of the study program, the opportunities were limited to a single science methods course. Prior to entrance into the teacher education portion of their degree plans, the PSETs in this study had completed four courses in sciences. Specifically, the recommended courses include environmental science, Earth science, conceptual physics and biology for educators. Despite the fact that these four courses cover the majority of concepts required of an elementary educator, the literature has shown that post-secondary science courses often fail to dislodge misconceptions or incorrect prior learning (Papadouris, Hadijeorgiou, & Constantinou, 2014; Trumper 1997). Also, due to the broad nature of the topics covered in the certification exam, there may be information that the PSETs may have not studied since middle or high school and have difficulty in understanding (Harrell & Subramaniam, 2014). Since the time in the single science methods course is limited to 15 weeks (45 hours), it was not possible to address all gaps. As such, data from practice exams and analysis of data from individual TEXES exam

results suggested that physics and chemistry topics should be the topics utilized for the microteaching lessons.

The results of the study supports the hypothesis that the microteaching assignment was responsible for the increase in the passing rate for the second attempt on the certification exam. The results are consistent with previous studies that report the effectiveness of microteaching for PSETs (Akerson, Pongsanon, Rogers, Carter, & Galindo, 2015; Goodson-Espy, Cifarelli, Pugalee, Lynch-Davis, Morge, & Salinas, 2014; Gunning & Mensah, 2010).

Limitations of the study and intervention

This study was limited by a few factors. To begin with, the study examined a single university's TPP. While the microteaching described in this study has been effective in covering content knowledge gaps using the 5E instructional model, it is not without its drawbacks. Not least among these drawbacks is the time commitment. The PSETs are allotted 30 minutes to deliver the lessons. Up to 24 participants per section can add up to 12 hours of classroom time per semester. The process is also demands a good deal of instructor time including extensive written feedback for draft lessons and out of class, face-to-face consultations with the PSETs in order to ensure that their final lesson is of a high quality. Gathering of lesson planning and teaching materials can also be a challenge as the participants often have unique approaches to teaching an assigned topic.

Conclusion

This study confirmed that changing the emphasis of the science methods course was successful in improving the content knowledge of PSETs who failed the initial attempt at the TEXES Core Subjects EC-6 exam. Specifically, a focus on physical science standards and reinforcing content and pedagogical knowledge through lesson planning and implementation during microteaching, positively impacted participant understanding of the content they are expected to know and be able to teach. Additionally, exposure to their peers' lessons, up to 23 lessons, served to reinforce physical science content. The results demonstrate that even with the small amount of student contact time available to science education faculty, impactful change can be achieved by tailoring the methods instruction so that the teaching candidate has the opportunity to bridge their own content knowledge gaps while practicing their teaching craft.

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