Successful Instruction for Diverse Student Populations: Culturally-Responsive Pedagogy in Pre-Service Teacher Programs

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[**Abstract**] The Training Future Scientist Program (TFSP) was developed and implemented at a predominantly White Midwestern university for mostly White female preservice teachers (WPSTs) to teach innovative pedagogical approaches for elementary science education methods course during the Fall 2015 to Spring 2018. TFSP draws synergistically upon sociocultural theory, and utilized co-teaching practices, the Biological Sciences Curriculum Study (BSCS) 5E Learning Model (Bybee, 2006), and the caring in action approach advocated by Geneva Gay (2010) and Gloria Ladson-Billings (1989). The primary objectives for the elementary teachers were to: 1) identify the fears and/or worries PSTs have when they teach science to culturally diverse underserved students, and 2) identify the specific experiences during the practicum that support female WPSTs to overcome their fears and/or anxiety before student teaching? The mentorship of an African American researcher, intended to model culturally responsive approaches, grounded in authentic philosophies to influence the WPSTs' teaching practices. The program underscored the value of learning innovative pedagogical interventions employed prior to student teaching and equipping future teachers to navigate culturally diverse classrooms effectively. The implications and results of these pedagogical approaches taught in the program are vital for enhancing science teacher education programs to better serve culturally diverse and underserved student populations.

[Keywords] culturally responsive teaching pedagogy, K-12 pre-service teachers, biological science curriculum study 5E learning model, inquiry

Introduction

Will (2022) reported that teachers of color can have a significant impact on the social-emotional and academic development of all students. One of the primary responsibilities of teacher education programs today is to prepare predominantly White female pre-service teachers (WPSTs) for elementary and secondary classrooms. Despite the prevalence of courses in multi-cultural education and culturally relevant pedagogy, there are still gaps in the preparation of these teachers (Pilitus & Duncan, 2012; Justi & van Driel, 2005; Justi & Gilbert, 2002). Weak science backgrounds and negative experiences in science prior to entering teacher preparation programs often hinder WPSTs' readiness (Hestness et al., 2011; Knaggs & Sondergeld, 2015; McDonnough & Matkins, 2010). This veteran African American female researcher, with 17 years of experience as a secondary science teacher and over 20 years as a research scientist, accepted a tenure-track teaching position at a predominantly White institution in the Midwest in 2014. Drawing on her successful teaching experience in an urban Midwest school district, this teacher/researcher designed a blueprint to train future PSTs in elementary and secondary science methods courses who are predominantly White.

This training program provided predominantly WPSTs with various pedagogical experiences, including reading and reflecting on culturally relevant materials, creating safety manuals, immersive training in the Biological Sciences Curriculum Studies (BSCS) 5E Learning Model, transforming cookbook labs into inquiry-based labs, and practical teaching experiences in elementary schools or after-school settings. The first and last day surveys gauged WPSTs' fears and progress. By amplifying African American women's voices and pedagogy, the program in education before PSTs engaged with diverse underserved students. We addressed these gaps in the literature by addressing the two following research questions: 1) What is the W PSTs biggest worry and/or fear about teaching science in an after-school practicum for diverse underserved groups? 2) What specific experiences during the practicum support female WPSTs to overcome their fears and/or anxiety before the practicum experience?

Theoretical Framework

Lev Vygotsky's sociocultural theory provides a lens to understand the effective preparation of WPSTs for teaching science to diverse students (Vygotsky, 1978). This research project aligns with Vygotsky's emphasis on teaching and learning in the zone of proximal development and cultural mediation, aiming to bridge the theory-to-practice gap in teacher education.

Literature Review

In the US, diverse underserved groups comprise a large percentage of students educated in poorer, urban and rural school districts, while the majority of the teachers are White females from middle-class families (U.S. Department of Education, 2016). Divergence in the racial, cultural and socioeconomic demographics between these students and their teachers causes incongruence in many domains (Farmer-Hinton, 2006; McDonough, 1997). In a study by the US Department of Education (2016), it was reported that most of these urban schools are filled with predominately White females who have taken courses in multicultural education and culturally relevant pedagogy, but more experiences are still needed. These add to the inequities in public education for diverse underserved groups that continue to plague the US system of education (Farmer-Hinton, 2006; McDonough, 1997; & US Department of Education, 2016).

Vygotsky's Sociocultural Theory

Lev Vygosky (1978) had three ideas in mind when teaching children science. The three ideas were: 1) the zone of proximal development; 2) cultural mediation; and 3) the importance of play. Jean Piaget (1896-1980) believed in cognitive constructivism when coupled with interaction with objects and phenomena using science discovery like the processes involved in using BSCS 5E Learning Model (Bybee, 2006) to teach science, science learning will be available to the learner. Vygotsky (1987) presupposes that learning occurs first between people and then for the individual. Vygotsky argues that combining these experiences with intellectual operations guided by language - the benefits are stronger than just allowing these PSTs to just keep repeating certain experiences.

Vygotsky (1987) identified the zone of proximal development as the key concept in understanding the theory. He defines the zone as the distance between the actual developmental level as determined by independent problem solving and the level of potential development through problem solving under adult guidance or in collaboration with more capable peers (p. 86).

Another group of researchers called this zone the level of potential a learner has when provided access to proper instruction either from a teacher or an experienced peer (Puntambekar and Hubscher, 2005). Bruner (1985) stated that a learner's zone of proximal development allows the learner to work on a difficult task as long as the teacher and/or experienced peer works with them. Therefore, the learner gleans knowledge and skills from the individual with more knowledge to accomplish the task.

Coteaching Benefits for PSTs

Petit (2017) discussed how using as an integral component such as co-partnering and professional learning early in PSTs development was achieved through purposeful co-planning and relationship building. This study was completed with the supervising teachers these PSTs were assigned to, which is similar to the research of Ambrosetti et al. (2014) and Gut et al. (2014). All of these researchers believed the better prepared and confident these PSTs are during their coteaching experiences the more successful they will be during their first year as teachers.

Colette Murphy (2016) in her book *in Teacher Education* describes an innovative pedagogy for excellence. This researcher's goal was to improve the relationship between PSTs and the in-service teachers they were assigned to. The model Murphy (2016) uses to implement is coplanning, copractice and coreflection. During coplanning each participant has a joint responsibility and/or role to facilitate the information presented to the students. The primary goal during coplanning is to design effective lesson plans that will enhance and promote science learning and understanding for the elementary students. Copractice describes the role of coaches exhibiting during the implementation of the lesson plan and/or activities. Ideally coteachers rotate when they are up instructing the students based on their level of expertise in the content and/or activity they are presenting to the students. The primary goal during copractice is for each coteacher to anticipate one another's moves.

Coreflection is the final process used in this model and is critical for coplanning for the next phase of the teaching. During coreflection each coteacher reflect on what worked and what did not work as smoothly as desired. To improve the next session coteachers might have to seek additional tools such as advice from colleagues, books and/or online resources that model a more effective way to move forward. Overall, the perfect relationship involves one coteacher leading and the other coteacher assisting; then as the lesson progresses the coteacher assisting moves into the leader role and the leader coteacher assists the new leader.

Elementary PSTs' beliefs and fears in teaching science curriculum

In science education, the beliefs and fears PSTs possess can be implicit and explicit. These fears can be centered on the students, classroom, and the science content learning. Often PSTs cannot articulate their beliefs and fears, while other times they are reluctant to express this anxiety because many of their beliefs and fears are highly contextualized (Leinhardt, 1990). Eick and Reed (2002) found PSTs are influenced in their teacher training programs by their own experiences from their science courses and/or PST training programs. PSTs and/or teachers routinely report how inadequate they feel due to a lack of preparation in teacher programs; weak science content knowledge; and/or negative experiences with science as a student (Hestness et al., 2011; Knaggs & Sondergeld, 2015; McDonnough & Matkins, 2010). These deficiencies lead to PSTs and/or teachers using strategies to simplify the science instruction; teach as little science as possible; rely heavily on the textbook, kits and/or worksheets; or not teach science at all (Harlen,W., 1999).

Bryan and Atwater (2002) contend the process of learning to teach begins with making sure the PSTs' beliefs about teaching and learning are explicit. Ucar (2011) reported teacher education science methods courses play an important role in influencing the attitudes and beliefs of PSTs. O'Brien et al., (1999) linked self-efficacy in a certain field to the probability of an individual choosing that career. Webb et al. (1993), Gilligan (1982), and Obidah et al. (2004) indicate caring is a value, an ethic and a moral imperative that moves PSTs from self-determination into being socially responsible for the diverse underserved groups they teach.

PSTs and Culturally Responsive Caring and Culturally Relevant Teaching

Culturally responsive caring as a part of the education process focuses on "caring for" instead of just *caring about* when teaching diverse underserved groups. Caring about demonstrates feelings of concern for one's own state of being, while caring for involves active engagement in producing a positive impact on others. Caring for also encompasses a combination of concern, compassion, commitment, responsibility and action (Garza et al., 2014, p. 1).

According to Gloria Ladson Billings (1989) reports that culturally relevant teaching serves to empower students to examine and critique educational content and processes, then ask how this material is and learn truly impacting the meaning and understanding of the world they live in. Culturally relevant teaching also supports social, cultural, and academic success which is usually missing in most schools when teachers are not trained in how to use this type of effective pedagogy when working with underserved students.

The BSCS 5E Learning Model is an effective strategy to teach PSTs how to design lesson plan using inquiry-based pedagogy. The model is divided into five phases: engagement, exploration, explanation, elaboration and evaluation. See Table 1. This model has been used extensively in curriculum development and professional development of science teachers and pre-service teachers to promote learning at all grade levels (Bybee et al., 2006).

Impact of a Science Practicum for Elementary PSTs

Crowther and Cannon (1998) characterized the impact of a practicum during PSTs student teaching. Multiple studies further indicate sufficient science content knowledge is the primary key to ensuring elementary and secondary PSTs and/or new teachers teach inquiry-based science (Kind, 2009; Santau et al., 2014; Weiss et al, 2001. Appleton (2007) reports that in the absence of this preparation, elementary PSTs and/or teachers do not teach science and/or expository methodologies, which hinders students' ability to develop scientific literacy and/or an interest in science.

Structure and Format of the Training Future Scientist Program

Overview of Training Future Scientists (TFS) Program for Elementary PSTs

This research project spanned six semesters and aimed to introduce predominantly WPSTs to culturally relevant teaching and inquiry pedagogy in science courses. The study began with the WPSTs completing a survey to understand PSTs' fears and worries before immersive experiences.

PSTs created introductory slides and participated in the Draw-A-Scientist Test. Table 2 outlines the experiences the WPSTs participated in to prepare them for the practicum experience at the two sites discussed below. The BSCS 5E Learning Model boot camp was key to their success in the practicum which each teaching team produced a group microteaching assignment that was implemented to their peers and grade level BSCS 5E Learning Model lesson plan they implemented in the practicum. The final activities the WPSTs underwent were daily reflections after each practicum visit and culminating research presentations sharing the results from their grade level they taught. See Figure 2. The final activities included a comprehensive final exam and exit survey to assess pedagogical knowledge and beliefs. Table 2 displays the expectations for the elementary PSTs for the science methods course.

Description of the Training Future Scientist Program

Vygotsky's Sociocultural Theory

Lev Vygotsky's sociocultural theory, emphasizing the zone of proximal development, cultural mediation, and the importance of play, provides a framework for understanding science education (Vygotsky, 1978; Murphy, 2012). Coupled with Jean Piaget's cognitive constructivism, the theory underscores the role of social interaction in learning (Bybee et al., 2006). Coteaching opportunities allow PSTs to apply the 5E Learning Model collaboratively, aligning with Vygotsky's concept of scaffolding and social interaction (Vygotsky, 1978). The zone of proximal development, central to Vygotsky's theory, emphasizes the role of knowledgeable peers or instructors in advancing learning (Puntambekar and Hubscher, 2005). By integrating inquiry-based lesson plans with the BSCS 5E Learning Model, PSTs engage with diverse learners effectively.

Coteaching with PSTs

Given the increasing diversity in classrooms, inquiry-based teaching, and coteaching are crucial (Meyer & Crawford, 2011). This study facilitated early coteaching experiences for PSTs, enhancing their readiness for inclusive classrooms (Petit, 2017). Co-planning, co-practice, and co-reflection emerged as effective pedagogical pillars (Murphy, 2016), fostering collaborative learning environments where both PSTs and in-service teachers grow.

Inquiry & BSCS 5E Learning Model

The BSCS 5E Learning Model offers a structured approach to inquiry-based teaching, empowering PSTs to design effective lesson plans (Bybee et al., 2006). WPSTs' exposure to inquiry teaching practices in science methods courses lays the groundwork for effective teaching in diverse settings. Providing the WPSTs access to inquiry teaching and learning practices in the science methods course became the foundation for the WPSTs' teaching, learning, and implementation of their lesson plans to their assigned diverse underserved groups in the science practicum. PSTs underwent a boot camp to learn and understand the BSCS 5E Learning Model (2006) which included readings, assignments, and hands-on activities. They transformed cookbook labs into inquiry-based activities and presented them to their peers.

Culturally Responsive & Relevant Teaching

Culturally responsive teaching acknowledges the cultural backgrounds of students, enhancing engagement and academic achievement (Gay, 2010). By situating learning within students' lived experiences, teachers can foster a supportive learning environment (Ladson-Billings, 1994). Culturally responsive caring emphasizes active engagement and empathy in teaching diverse students (Garza et al., 2014). WPSTs implemented this pedagogy serving in the practicums with diverse underserved students and their responses on the post survey revealed the changes in their philosophies compared to the first day survey.

Science Practicum for Elementary PSTs

Practicum experiences play a pivotal role in PSTs' development, particularly in teaching science (Crowther & Cannon, 1998). Building science content knowledge is crucial for effective science instruction (Kind, 2009). Vygotsky's (1978) sociocultural constructivism underscores the importance of social interaction in learning and guiding PSTs' development in the practicum setting. Tables 2 displays the typical timeline the WPSTs experience in this immersive inquiry-based elementary immersive science methods course. Figure 2 displays an example of a research poster produced by an elementary PST as a culmination to the practicum at an after-school program.

Practicum - Immersive Experiences

The WPSTs were immersed in experiential settings in two locations. Elementary WPSTs were placed in two different settings, negotiated before the semester, which involved after-school programs at two sites. Site A served predominantly underserved White students with White staff, while Site B served predominantly diverse underserved students with diverse staff. Both sites provided classroom space for instruction, and materials were provided through university grants and private donations. Elementary PSTs implementing group lesson plans in coteaching teams and reflecting daily.

Final Pedagogy

The program concluded with a comprehensive final exam and exit survey to assess pedagogical growth and understanding.

Research Questions

We address these gaps in the literature by addressing the three following research questions: 1) What is the W PSTs biggest worry and/or fear about teaching science in an after-school practicum for diverse underserved groups? 2) What specific experiences during the practicum support female WPSTs to overcome their fears and/or anxiety before the practicum experience? The questions were administered to six cohorts in a longitudinal study to predominately WPSTs that were female (n= 176) between Fall 2015 and Spring 2018. These PSTs were enrolled in an immersive elementary science methods course facilitated by an African American female scientist/science educator.

Methods and Research Contexts

Participants and Setting

The sample consisted of ~200 PSTs enrolled in two sections of an immersive science methods undergraduate course at a public university, situated in the Midwest, and the data were collected over the course of eight semesters. Of the 200 PSTs enrolled, 176 PSTs completed the first day and exit surveys. All of these PSTs were planning to become elementary education teachers, 96% were White females and 25% expressed a desire to work with diverse underserved groups. There were 11 – 24 PSTs per section/semester; and two to five PSTs comprised a coteaching team per grade level.

Two experiential settings were used: *Site A* served predominately underserved White students and staff and *Site B* served predominately diverse underserved students and staff. The majority of the elementary students at both sites received free and/or reduced lunch at their schools and, regardless of their ethnicity, all students were from diverse underserved groups. These diverse underserved groups refer to students that have a different culture, ethnicity, socioeconomic and/or language than those found in the dominant groups in the US and the PSTs. Each site provided a classroom and/or open space to implement instruction for each grade level coteaching team. Grants from the university and private donations provided the materials needed for the PSTs to implement the lesson plans for the diverse underserved groups.

The primary goal of this research was to examine the impact of participation on white PSTs fears in an immersive science methods course before student teaching. The data sources were pre- and post-surveys which captured the WPSTs reflections of their fears of teaching science to diverse underserved groups and the supports during the immersive practicum that helped them to overcome their fears.

Data Analysis

The initial opened-ended responses from first-day (pre) survey and exit (post) survey, with some participants providing multiple responses indicated by the number in parentheses *N* of responses = 176 (271), Q1; *N* of responses = 176 (335), Q2 from this longitudinal study were analyzed using open coding, as outlined by Strauss and Corbin (1998b) then examined to identify the emerging themes using axial coding and selective coding from the experiences of the PSTs in the program to the responses as stated above. See Tables 3-5 for the themes that were identified. The frequency distribution of the themes was analyzed using Statistical Package for the Social Science (SPSS) software to conduct tests of association in two-way contingency table (Green & Salkind, 2003), comparing the distribution for the themes within each question by the two sites. The rationale for this quantitative analysis of the qualitative data was to determine if there was a difference in the PST responses since the diverse underserved groups at each site had different ethnic compositions. See Tables 6-8 for the crosstabulations that were examined.

Variables

The independent variable for this research study was practicum site: site A and site B. The dependent variables were the: 1) reflective foundational data themes and categories for the responses for the two survey questions; 2) the parameters that were kept constant were: a) same researcher as the facilitator of each section of the course; b) same practicum sites to implement the practicum; and c) same strategies to prepare the PSTs to teach in the practicum.

Research Positionality
Researcher positionality supports and is important for this study because the researcher is a more knowledgeable other and a veteran teacher that used these pedagogies for over 17 years. While the WPSTs in this study identified as white and female, the researcher is an African American female. Her experience as a: 1) scientist; 2) science educator; 3) mentor; and 4) mother required her to serve as a role model providing academic, social, physical, and emotional support. The researcher's previous roles required her to serve as a role model providing academic, social, physical, and emotional support irrespective of the environment. The researcher used all of her experiences as a researcher and scientist to design this study with the hope of producing future teachers that were not afraid to teach diverse students whether in an immersive after-school program, during student teaching and/or in their future classroom.

Findings and Discussion

In this study, we sought to unearth why female WPSTs fears/worries before/after participation in an immersive after-school practicum. The findings and discussion are organized in two parts: 1) quantitative results, Tables 3-5; and 2) qualitative results, excerpts for the first- day (pre) survey and from the exit (post) survey. Table 3 revealed five themes from the first day (pre) survey. Table 4 revealed five themes from the exit (post) survey. When the survey results were compared from the first day (pre) survey six themes were revealed, see Table 5. Table 6 compared the results from both sites A & B which revealed five themes. Table 7 revealed seven themes by comparing the theme distribution for fears and anxiety from the first day *(pre)* survey and experiences from the exit *(post)* survey initial concerns. Table 8 revealed eleven themes by comparing initial concerns from the first day *(pre)* survey and expectations from the exit *(post)* survey. The discussion that connects these results to the literature review follows each table and excerpts.

Quantitative Results
The results in Table 3 displays the results from the first day survey open-ended question about PSTs greatest fear and/or worries to teach science in a practicum that serves diverse underserved groups. The theme with the greatest number of responses is teacher concerns with a total frequency of 196 (73 %). The other themes mentioned were 10 % or less of the responses.

The results in Table 4 are from the exit survey when PSTs were asked to disclose what specific experience helped the PSTs overcome their fears and/or anxiety to teach science in a practicum that serves underserved groups. Although there were 14 different categories the PSTs revealed, these were reduced to five themes. The greatest number of responses were under the theme of teacher concerns with a total frequency of 226 (68%). All the other themes were 13 % or less of the responses.

The results display the cross-tabulation results comparing the first-day survey responses between sites A and B (Table 5). Teacher concerns were the most common theme for both sites with over 70% of the statements involving their worry and/or fear. The Fisher's Exact Test (p = 0.839) indicated no differences in the types of themes reported by PSTs at Site A and B. For the exit survey question concerning experiences, Table 6 shows the cross-tabulation results comparing responses between sites A and B. The most common theme was once again teacher concerns for both sites, with over 65% of the statements involving this. The Fisher's Exact Test ($p = .181$) indicated no differences in the types of themes reported by PSTs at Site A and B.

A Chi-Square Test of Association was conducted to compare the theme distribution for fears and anxiety from the first day survey and experiences from the exit survey (Table 7). The distribution of themes for the first question was found to not be the same as the distribution of the themes in the second ($x^2 = 60.20, df = 6, p < .001$). Post hoc analysis showed that three themes had different proportions for the pre-and post-questions: practicum site, time management, and workload. Practicum site, which was not an initial theme, became one while time management and workload were no longer mentioned.

A Chi-Square Test of Association was also conducted to examine initial concerns from the first day survey and expectations from the exit survey (see Table 8). The overall distribution of themes for the initial question was not the same as the distribution for the themes in this post question ($X^2 = 399.102$, $df = 10$, $p < .001$). The post hoc comparisons found seven themes with different proportions for these questions. Instruction, student connection, and teacher confidence were not initial themes. Pedagogy became a more frequent theme at the exit survey, while teacher concerns, time management, and workload were mentioned less.

The foundational data for each question is found in Tables 3-5. Tables 6-8 revealed cross tabulation results comparing sites A and B for the pre-and post-survey questions. These differences may be attributed to the use of Vygotsky's (1978) sociocultural constructivism theory as theoretical framework for this research. Also contributing to these differences may have been the use of pedagogy based on 1) the philosophy of Geneva Gay (2010) "caring in action"; and 2) enabling the PSTs to work in coteaching teams. Teaching science in their zone of proximal development may have contributed to the differences in the pre-and post-responses. This approach to training these PSTs is associated with a shift in their fears, worries, and anxieties, which is anticipated to be critical to their success in their future classrooms with diverse underserved groups.

Qualitative Results

Pre-Survey. Six themes characterized PST responses to Pre-survey Question One (see Table 3 and cross tabulation results Table 6). The predominate theme for this question was **teacher concerns.** The primary subcategories of teacher concerns were lack of confidence and student behavior.

Pedagogy emerged as the second theme. All of these responses affirm the research of Hestness et al. (2011) and other researchers when PSTs report a weak science content knowledge and/or negative experiences with science. The sample responses for teacher concerns under the sub-category **student behavior** were based on what the PSTs saw during the classroom observation or from prior anxiety these PSTs brought with them when teaching (Table 9).

These responses support the research of Leinhart (1990), which states some PSTs cannot articulate their beliefs and fears, while other times they are reluctant to express this anxiety because many of their beliefs and fears are highly contextualized. Such implicit and explicit fears have been associated with demeaning and devaluing treatment of students from diverse underserved groups (Good & Brophy, 2003; Harry, 1992; Oakes, 1985; Papageorge & Gershenson, 2016). These responses concur with the research of Good & Brophy, 2003; Harry, 1992; Oakes, 1985;

Papageorge & Gershenson, 2016. Statements, such as these, indicate the PSTs allow their fears and worries to demean and devalue these diverse underserved groups.

Post-Survey. Five themes characterize PST responses to Post-Survey Question One (Table 4 and Cross Tabulation results Table 7). The predominant theme for Post-Survey Question One was also teacher concerns but the leading categories were different from Pre-survey Question One. As you recall the Pre-survey Question One primary categories were: lack of confidence and student behavior; but for Post-Survey Question Two the three leading subcategories of teacher concerns were: teacher confidence, behavior management and fear.

The responses indicating **teacher concerns** on the post survey support the research of Crowther and Cannon (1998), indicating the impact of a practicum during student teaching (Table 10). Since this practicum is implemented before student teaching, some of the resistance to changing Kagan (1992) reports might be reduced, which can produce PSTs with more confidence to teach science.

The responses focused on sub-category behavior management under the **teacher concern** theme share the importance of the PST learning how to ensure the students valued their behavior management expectations (Table 10). This was a challenge at times because the PSTs were only at the practicum site twice a week, for 4-5 weeks, and they could not control the behavior management expectations when they were not there. These responses support the additional research of Crowther and Cannon (1998) on the benefits of a teaching practicum that includes a co-teacher. Dweck (2008) research reports providing PSTs access to coteaching opportunities can change a PST's mindset and this was evidenced in some the PST responses. Since this practicum includes a co-teacher, this experience is anticipated to better prepare these PSTs during student teaching and in their future classrooms.

The responses around fear emerged as the third subcategory under the **teacher concern** theme yet appeared in less than 24 responses (Table 10). These responses included three sub-categories: lack of confidence, experience and funding. Some PSTs still felt a lack of confidence at the end of this practicum experience, but the majority of the PSTs that participated in this practicum before student teaching found this experience to be an opportunity to reduce their fears, worries and anxieties. These responses indicated more work still needs to be done to ensure we produce PSTs that will teach science and use expository methodologies as discussed in Appleton's (2007) research. In addition, the research of (Edelson & Reiser, 2006; Gotwais & Songer, 2006; NRC 2007; & Robinson-Hill, 2018) indicated the importance of an emphasis on scientific practice involving inquiry and discovery learning. Such emphasis may be of help to these White female PSTs. The rationale for using these pedagogies with these PSTs can ensure these PSTs will not hinder diverse underserved groups from access to scientific literacy and will address their interest in science.

The third theme from responses to Post-Survey Question One was **student concerns**. This was also the third theme for Pre-survey Question One, with a similar frequency < 10 %. The primary category for Post-Survey Question One was student engagement. Modeling the constructivist and inquiry orientation that mimic an authentic science approach was what NRC (1996) indicated all teachers should do. This program provided these PSTs access to the pedagogy of Geneva Gay's (2010) *caring in action* and multicultural teaching matched for the diverse underserved groups before student teaching, which hopefully will give them a springboard they can use in their future experiences and decrease their theory to practice gap.

Conclusion

The TFS pedagogy discussed in this project has the potential to benefit future teachers, particularly White female pre-service teachers (WPSTs), by addressing their biases and fears when teaching diverse marginalized and underserved students in K-12 settings. De Royston et al. (2020) emphasize that Black women educators possess valuable teaching methods grounded in intellectual property and practical knowledge, challenging the notion of them being inherently "magical" or mysterious. The main contribution of this study is to uncover the fears and concerns of WPSTs that are female before engaging in student teaching and demonstrate how culturally relevant teaching and the BSCS 5E Learning Model can transform these PSTs and alleviate their apprehensions about teaching science to diverse underserved students.

Incorporating a practicum experience within elementary science method courses, where WPSTs teach science in teams using the BSCS 5E Learning Model, has shown promise in reducing the fears of White female PSTs when teaching diverse underserved groups, as well as addressing their biases and assumptions. Moore (2008a), Nieto (2000), and Rodriguez (1998) argue that it is essential for PSTs to confront deficit notions in order to become teachers who promote culturally responsive teaching, especially when serving diverse underserved groups. This shift in perspective, leading to a transformation of PSTs, as described by Zapata (2013), is crucial in producing PSTs who can drive change in teacher education.

Authors (2022) stress the importance of rethinking the structure of teacher preparation programs to produce competent and confident White female teachers capable of effectively teaching students from diverse cultural and ethnic backgrounds. Pedagogical designs incorporating culturally responsive teaching, inquiry-based learning, and the BSCS 5E Learning Model are expected to bridge the theory-practice gap often observed in teacher education programs.

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Appendices

Table 1
Biological Science Curriculum Study 5E Learning Model (Bybee, 2006)

Phases	Summary
Engagement	The teacher accesses the students' prior knowledge for the established learning objectives and allows the students to engage in a new concept through the use of short activities that promote curiosity.
Exploration	The teacher allows the students with a common base of activities within which current concepts and/or misconceptions and process skills are identified.
Explanation	The teacher focuses the students' attention on specific issues noticed in the Engagement and Exploration phases that can be corrected and/or lead the students to deeper understanding.
Elaboration	The teacher challenges the student understanding of the new concepts and provides the student with new experiences to participate in.
Evaluation	The teacher provides an opportunity for the students to access their understanding and abilities, which provides the teacher with an opportunity to evaluate student progress toward achieving the learning objectives.

This table displays the five phases of the Bybee et al. (2006) BSCS 5E Learning Model. This model has been used extensively in curriculum development and professional development of science teachers and pre-service teachers to promote inquiry learning at all grade levels.

Table 2
Elementary PSTs Semester Timeline & Expectations

Weeks	Agenda	Expectations & Outcomes
1	• Complete First-day survey • Introduction activities • Identify grade level to teach • Identify coteaching team	• Identify PSTs fears • Complete Draw-a-Scientist Test(DAST) • Meet Coteaching PSTs
2-3	• Begin student & researcher introductions • Begin culturally relavant immersion/reflections • Immersion Exploring Science Safely • Creation of Safety manual & contract • Classroom observation at practicum site	• Present Introduction slides Identify PSTs rationale for teaching • Identify biases for working with marginalize students & teachers • Identify & design a Safety manual & Contract to use in the practicum & future classroom • Visit practicum site to observe students and teachers
4-6	• BSCS 5E Learning Model	• Learn attributes of the BSCS 5E Learning Model

Weeks	Agenda	Expectations & Outcomes
	bootcamp	through reading & critiquing a lesson plan using the BSCS 5E Learning Model • Participate in researcher-led inquiry hands-on, minds-on labs to learn the inquiry process & rules • Learn how to transform a cookbook lab into an inquiry lab with coteachers for microteaching activity • Design BSCS 5E Learning Model group lesson plan to implement at the practicum with coteachers
6-10	• Implementation of coteaching Micro teaching activities • Prepare Teaching Resource Box • Classroom visit #2, implement pre assessment & distribute Student Science NBs	• Each coteaching team will implement one micro teaching activity to their peers before the practicum begins as practice in teaching science • Bring in materials for use in the practicum to place in Teaching Resource Box • Visit practicum site again to implement pre assessment and set-up Science NBs to use in the practicum • Evaluate pre assessment & determine if revisions need to be made to the lesson plan before the practicum begins
11-13	• Practicum begins • Complete & submit Daily reflections • Document practicum student progress with iPads • Monitor student progress in Science NBs • Complete Post assessments and finish the practicum; share class videos	• Each coteaching team will participate in an ice-breaker then implement one to two phases of the BSCS 5E Learning Model lesson plan • Write & submit a detailed reflection after each practicum visit • Create first-draft of research poster week 12 (F2015 – Fall 2016) • Summarize each phase after the phase is taught for first draft of manuscript (Spring 2017) • Evaluate student mastery by implementing post assessment
14-16	• Return to classroom • Evaluate practicum students' pre/post assessments and Science NBs • Participate in Science symposium to showcase one practicum student in grade level (F2015 – Fall 2016) • Create an outline for a manuscript to share practicum outcomes from one student (Spring 2017) • Implement Draw-a-Scientist Test II (DAST II) • Implement final exam • Implement Exit Survey	• Compare pre/post assessments • Finish research poster for Science Symposium • Participate in Science Symposium • Combine all phase summaries for final draft of manuscript • Complete Draw-A-Scientist Test II (DAST II) • Complete & submit final exam • Complete & submit Exit survey

Table 3

Q1: What is the biggest worry and/or fear about teaching science in an after-school practicum for diverse underserved groups? (First Day Pre Survey)

Themes	Frequency	Percentage
Teacher Concerns	196	72%
Pedagogy	27	10%
Student Concerns	22	8%
Course Concerns	9	3%
Work Load	11	4%
Time Management	6	2%
Total	271	100%

Table 4

Q2: What specific experiences during the practicum helped you overcome any fears and/or anxiety you had before the practicum experience? (Exit Post Survey)

Themes	Frequency	Percentage
Teacher Concerns	226	68 %
Practicum Site	44	13 %
Student Concerns	33	10 %
Pedagogy	21	6 %
Course Concerns	11	3 %
Total	335	100 %

Table 5

Cross-Tabulation Results Comparing Sites A & B on First Day Worries/Fears

Themes	Frequency		% Within Site	
	Site A	Site B	Site A	Site B
Course Concerns	6	3	4.8%	4.9%
Pedagogy	11	16	8.9%	10.9%
Student Concerns	11	11	8.9%	7.5%
Teacher Concerns	88	108	71.0%	73.5%
Time Management	3	3	2.4%	2.0%
Work Load	5	6	4.0%	4.1%
Total	124	147	100%	100%

	p Value	Exact Sig. (2-sided)
Fisher's Exact Test	2.240	.839
N of Valid Cases	271	

Table 6
Cross-Tabulation Results Comparing Sites A & B on Experiences

Themes	Frequency		% Within Site	
	Site A	Site B	Site A	Site B
Course Concerns	2	9	1.2%	5.4%
Pedagogy	8	13	4.8%	7.8%
Student Concerns	18	15	10.7%	9.0%
Teacher Concerns	117	109	69.6%	65.3%
Practicum Site	23	21	13.7%	12.6%
Total	168	167	100%	100%

	p Value	Exact Sig. (2-sided)
Fisher's Exact Test	6.215	.181
N of Valid Cases	335	

Table 7
Cross Tabulation Comparing Initial Concerns and Later Experiences

	Frequency		% Within Site	
Themes	Concerns	Experiences	Concerns	Experiences
Course Concerns	9	11	3.3%	3.3%
Pedagogy	27	21	10.0%	6.3%
Practicum Site	0	44	0.0%	13.1%
Student Concerns	22	33	8.1%	9.9%
Teacher Concerns	196	226	72.3%	67.5%
	Time Management	6	0	2.2%
				0.0%
Workload	11	0	4.1%	0.0%
Total	271	335	100%	100%

$x^2 = 60.20$, $df = 6$, $p < .001$, $n = 606$

Table 8
Cross Tabulation Comparing Initial Concerns and Later Expectations

	Frequency		% Within Site	
Themes	Concerns	Expectations	Concerns	Expectations
Course Concerns	9	9	3.3%	3.1%
Fears	0	1	0.0%	0.5%
Instruction	0	31	0.0%	16.2%
Pedagogy	27	61	10.0%	20.7%
Student Concerns	22	15	8.1%	5.1%
Student Connection	0	11	0.0%	3.7%
Teacher Concerns	196	10	72.3%	3.4%
Teacher Confidence	0	154	0.0%	52.2%
Teacher Support	0	3	0.0%	1.0%
Time Management	6	0	2.2%	0.0%
Workload	11	0	4.1%	0.0%
Total	271	335	100%	100%

$x^2 = 399.10$, $df = 10$, $p < .001$, $n = 566$

Table 9
Q1: What is the biggest worry and/or fear about teaching science in an after-school practicum for diverse underserved groups? (First Day Pre Survey)

Themes & Frequency (%)	Sub category	Sample responses
Teacher concerns 72 %	*Lack of Teacher confidence*	• *"My biggest fear or worry about the practicum is not being able to explain the content in a way my students can understand" (Fall 2015, Site B, Line 27).* • *"My biggest fear in the science practicum is that I will forget and mess something up and confuse my students" (Fall 2016, Site A, Line 31).* • *"…That I won't know science well enough" (Spring 2017, Site A, Line 83).* • *"My biggest fear about the science practicum is either miscommunication with the professor or my co-teacher's (Spring 2018, Site B, Line 86).*
	Student behavior concerns	• *"I feel that I will spend most of my time classroom managing since they are use [sic] to free-time and unstructured play" (Fall 2015, Site A, Line 10).* • *"I hope that we are able to change their behavior because it will be hard to get anything done otherwise" (Fall 2015, Site B, Line 26).* • *"I worry that I will have a hard time keeping the students under control since I know they will have a lot of energy after being at school all day" (Fall 2016, Site B, Line 139).* • *"For this practicum, my biggest fear would be the behavior issues of the students because we were told they have no structure" (Spring 2017, Site B, Line180).*
Pedagogy 10 %	*Lack of teacher knowledge*	• *"I am awful at science, and science does not really interest me, so teaching it does scare me" (Fall 2016, Site B, Line 123).* • *"My biggest worry is that I am not a very good science student so I am worried that I will not be able to teach it effectively or that I will pass on my insecurities to my students" (Spring 2017, Site A, Line 148).*

Table 10

Q2: What specific experiences during the practicum helped you overcome any fears and/or anxiety you had before the practicum experience? (Exit Post Survey)

Themes & Frequency (%)	Sub category	Sample responses
Teacher concerns 68 %	*Teacher confidence*	• *After going to the site, I feel better prepared with what to do and not do when teaching students science (Fall 2015, Site B, Line 108).* • *I overcame being timid of teaching my lesson (Spring 2016, Site A, Line 194)* • *I feel like more experiences with children and in the classroom, will help me with my anxiety and fears (Spring 2016, Site B, Line 238).* • *I realized that the more I "go with the flow", the more effective my management and teaching will be (Fall 2018, Site A, Line 316).*
	Behavior management	• *"We had to enforce the rules throughout the course of the practicum, not knowing exactly what the teachers enforce when we are not there" (Fall 2015, Site B, Line 95).* • *"I learned that they will test you, but if you are consistent and firm, they will respect you" (Fall 2015, Site A, Line 51).* • *"I was able to stay calm and come up with different strategies to keep students on task before I got there so I had a variety of methods to try out" (Spring 2016, Site A, Line 185).* • *"Once I saw my colleague calm the kindergarten class down by using instructional methods that motivate children and maintain in their attention, I was no longer worried the students would be uninterested in the topic being taught" (Spring 2017, Site B, Line 245).*
	Fear	• *"Still have some fear of teaching a lot of students in my own classroom"* (Fall 2015, Site B, Line 23). • *"My anxiety never fully subsided during the practicum"* (Fall 2015, Site A, Line 23). • *"I know how to do science on my own, but having students involved was a whole new thing that I was unsure if it would work effectively"* (Fall 2018, Site B, Line 331).

Figure 1

Draw-A-Scientist Test (DAST #1)

Draw – A Scientist – Test I

1. Who do you believe can be a scientist ? (Circle one response)
   a. A male
   b. A female
   c. Boys & girls
   d. Yourself
   e. All of the above

In the space below draw a picture of a Scientist(s).

2. Who did you draw a picture of ? (Circle one response)

   a. An adult male
   b. An adult female
   c. A boy or girl
   d. Yourself
   A. All of the above
3. Explain below why you drew your picture.
4. Was your *picture* the same or different from the first Draw-A-Scientist Test picture you drew? (Circle one response) a. Same b. Different
5. Write a reflection to explain if your picture **matched** your response to Q#1 or **did not match** your response to Q#1.

Figure 2

Elementary PSTs Research Poster