The Training Future Scientist Program and eNVision Collaborative Project: A Redesign for Pre-Service Science Teacher Professional Development

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[Abstract] This article describes the *Training Future Scientist* program which was developed in partnership with the *eNVsion* program for a Professional Development School (PDS). It resulted in creating a unique environment for pre-service teachers (PSTs) to enhance their instructional skills in elementary science education classes. Though specialized approaches to traditional practicum courses, this partnership between a Midwest university and a local school district provided an opportunity for innovative teaching approaches, applicable for university and elementary school faculty, elementary education PSTs, and elementary students. This experiential project included courses in instructional and behavioral engagement, literacy practices and instructional methods for elementary science course. This article describes key features of the training program and its results, based on feedback collected university faculty, PSTs, and PDS students.

[Keywords] pre-service teacher training, professional development school, immersive, literacy, instructional and behavioral engagement, science instructional methods, training future scientist

Introduction

The Training Future Scientist (TFS)-eNVision project is a university-school collaboration using immersive learning and the TFS pedagogy at a predominantly White institution in the Midwest to train predominantly White female pre-service science teachers (PSTs). The goal of the collaboration was to develop an innovative pedagogy for this low-performing Professional Development (PDS) elementary school. The US Department of Education (2016) reported most urban schools are filled with predominately White female teachers, who take courses in multi-cultural education and culturally relevant pedagogy, yet gaps in preparation are prevalent.

The authors designed a project which sought to reveal the impact of an elementary science methods course that, when combined with courses in instructional and behavioral engagement and literacy methods that provided intentional exposure to culturally relavant and responsive practices at the PSTs and student's zone of proximal development (Gay, 2010 & 2018; Ladson Billings, 2006; Vygotsky, 1978). Kerr (2020) believes coteaching in a professional development experience that, like the TFS-eNVision project provided these PSTs, is beneficial for the development of future teachers. This experience also benefits the attitudinal changes among the future teachers. According to several researcher studies, PSTs have not been sufficiently prepared to meet the needs of today's students (Justi & Gilbert, 2002; Justi & van Driel, 2005; Pilitus & Duncan, 2012). Many PSTs feel inadequately prepared to teach science when they enter the teaching field (Hestness et al., 2011) with the culprit being weak science backgrounds and negative experiences with science as a student (Knaggs & Sondergeld, 2015; McDonnough & Matkins, 2010). This project will provide these PSTs the missing links the literature indicates is important for these PSTs to be successful in today's classrooms.

The researchers' primary objective of the TFS-eNVision program was to reveal the impact of a PDS partnership facilitated by two university faculty, 14-White female PSTs and a local low performing elementary school in the Midwest that served a diverse population of K-5 grade students. The first author, an African American woman, facilitated and created the TFS program, taught in a nine-hour immersive block, which uses culturally relevant pedagogy (Gay, 2010), inquiry, and the Biological Sciences Curriculum Study (BSCS) 5E Learning Model (Bybee, R. W. et al., 2006). The second author, a White woman, facilitated the PSTs' mastery of literacy, instructional practice, and behavior management through a student-centered and culturally responsive approach. This innovation to this teacher preparation program wants to reduce the White females fears, assumptions and bias when teaching diverse underserved students in grades K-5.

The Issues at Hand

According to the Indiana Department of Education (IDOE) achievement is defined by a school's performance compared to the state average on standardized tests. Schools that post scores below the state average tend to be labeled as low achieving. The elementary school with which we partnered, though posting some of the highest performance scores in the district, still achieved below the state average in English/Language Arts, Mathematics, Science, and Social Studies. The schools missed the target level in Mathematics by only .04%, but more than 50% of the students scored either below proficiency or approaching proficiency (neither of which is passing) (IDOE, 2021).

The TFS Pedagogy modeled Gloria Ladson-Billings' (2006) philosophy of culturally relevant pedagogy to address the problem many White female teachers grapple with and/or confront how and what to teach poor children of color. This study we designed to address and answer the questions of what impact the TFS-eNVsion PDS project has on White female PSTs and PDS participants. The perceptions of the study participants were then measured after involvement in the intense immersive experience using the BSCS 5E Learning Model, science inquiry and TFS culturally relavant pedagogy.

Key Considerations from the Literature

In the US, diverse underserved groups comprise a large percentage of students educated in poorer, urban and rural school districts with a large percentage of Bi-POC students, with the majority of the teachers are White females from middle-class families (USDOE, 2016). In the study by the USDOE (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 exposure to culturally relavant teaching is needed. White students taking courses in multicultural education and using culturally relevant pedagogy is not enough; this only adds to the inequities in public education for diverse underserved groups that continue to plague the US system of education (Farmer-Hinton, 2006; McDonough, 1997; USDOE 2016). The intense immersive experience provided by the TFS-eNVision program which incorporates inquiry and culturally relavant practices in teaching science, literacy, and implementing effective instructional and behavioral engagement hoped to be the missing link in PSTs development.

The primary author partnered with the eNVision program to implement the TFS pedagogy to train the PSTs how to teach science to students in grades K-4 using the TFS culturally relevant

pedagogy, inquiry, and the Biological Science Curriculum Study (BSCS) 5E Learning Model (Bybee et al., 2006) as shown in Table 1.

Table 1
Biological Science Curriculum Study 5E Learning Model

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 using short activities that promote curiosity.
Exploration	The teacher allows the students to participate in a common base of activities within which current concepts and/or misconceptions, 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.

Lev sky (1978) offered three insights into three considerations about teaching science to PSTs and children: 1) the zone of proximal development; 2) cultural mediation; and 3) the importance of play. Vygotsky (1978) presupposes that learning occurs first between people and then for the individual. Piaget (1964, 2003) believed that cognitive constructivism, when coupled with interaction with objects and phenomena using science discovery such as the processes involved in using BSCS 5E Learning Model (Bybee et al., 2006) to teach science, which will create more opportunities for science learning. This belief supports preparing PSTs to learn how to co-teach before student teaching and allowing these PSTs to participate first and then implement science lesson plans using the BSCS 5E Learning Model in this immersive experience.

Petit (2017) discussed how using as an integral component in early PSTs development. The outcomes of this research supported that quality co-partnering and professional development are achieved through purposeful co-planning and relationship building. This study was completed with the supervising teachers to whom these PSTs were assigned, which is confirmed by the findings of et al., (2014). Murphy et al. (2013) concur that co-teaching also provided teachers as well as PSTs a platform to reflect on theory and practice in their praxis. In addition, coteaching can improve PSTs and teachers' enjoyment of teaching science, a development of positive and sustainable teaching pedagogy which leads to an increase in student academic achievement, as is shown in this project.

Murphy (2016) described innovative pedagogy for excellence. The goal of this research was to improve the relationship between PSTs and the in-service teacher they were assigned to through the use of co-planning, co-practice, and co-reflection. During co-planning, each participant had a

joint responsibility and/or role to facilitate the information presented to the students. Murphy et al. (2013) states co-planning can reduce the PSTs and teachers from feeling isolated which influences the coteachers to teach the lesson instead of shifting the lesson to meet the differing needs of the students. Co-practice describes the role coteachers exhibit during the implementation of the lesson plan and/or activities. Ideally, co-teachers rotate when they are instructing the students based on their level of expertise in the content they are presenting or activity at hand. Co-reflection is the final process used in this model and is critical for co-planning to occur in the next phase of the teaching. During co-reflection, each co-teacher reflects on what worked and what did not work as smoothly as desired. In order to improve the next session, co-teacher might have to seek additional tools such as advice from colleagues or consult books and/or online resources that model a more effective way to move forward. Overall, the ideal relationship involves one co-teacher leading and the other co-teacher assisting. As the lesson progresses the assisting co-teacher moves into the leader role and the leader co-teacher assists the new leader.

Conceptual Framework

The conceptual framework for this research was informed by Gay's (2010 & 2018) culturally relevant teaching (CRT), Ladson-Billings (2006) culturally relevant pedagogy (CRP) and Vygotsky's (1978) teaching in the PST's Zone of Proximal Development (ZPD) and socio-cultural philosophies. These strategies and methods were integrated into the Training Future Scientist program with the goal that the PSTs would transfer these practices to the PDS classrooms. The rationale for the study engaged with a PDS site that personalized and enhanced the experience by honoring the mutual understanding and shared vision for teaching and learning for PSTs and mentor teachers. The TFS-eNVision program provided the PSTs an opportunity to: 1) serve at this low-achieving school for 210+ hours; 2) access to a higher level of collaboration with a veteran teacher and two veteran university professors; 3) weekly and daily reflections; 4) full immersion into the school culture; and 5) time to teach science on nine-consecutive days near the end of the practicum (Brown and Hill, 2021).

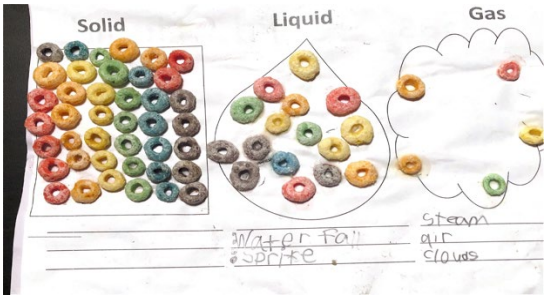
Pilot Study Context and Context

The pilot study, of the TFS-eNVision program was a university-school collaboration using immersive learning and the TFS culturally relevant pedagogy. The initial brainstorming of the TFS-eNVision program began with a conversation with the school principal to assess needs and design a program for the study participants. Included in the study were 14 PSTs, seven veteran certified elementary and 175 diverse underserved students in seven classrooms. In this way, the project provided exposure for the PSTs to 1) the authentic happenings in a low-achieving school; 2) less disruption of the teaching in these seven classrooms; and 3) access to two veteran educators that serve as professors at this predominately white university in the Midwest (Brown & Hill, 2021).

The TFS program embedded how to 1) use and reflect on culturally relevant teaching; 2) implement inquiry-based pedagogy using the BSCS 5E learning Model lesson plan (Bybee, et al., 2006); and 3) an opportunity to co-teach with a peer using Murphy's (2016) co-teaching model to foster positive relationships between the PSTs and the PST's in-service teacher. Each co-teaching team was required to integrate literature and writing in the inquiry science lesson plan each team designed. The lesson plans contained pre and post summative assessments; science data sheets;

and hands-on, minds-on activities that document the students' science understanding and learning, both formative assessments (see Table 2).

Table 2
Examples of Inquiry Formative Assessment Activities

Grade level	Explanations	Examples
K	This is a plant journal completed by each Kg student to document plant progress.	
1st	This is a graphic organizer first grade students completed to demonstrate the difference between the three types of matter.	
3rd	This is an activity third-graders participated in to measure sound vs. distance using a Likert scale. The Likert scale distinguished how much sound the students could hear as the distance increased and decreased.	

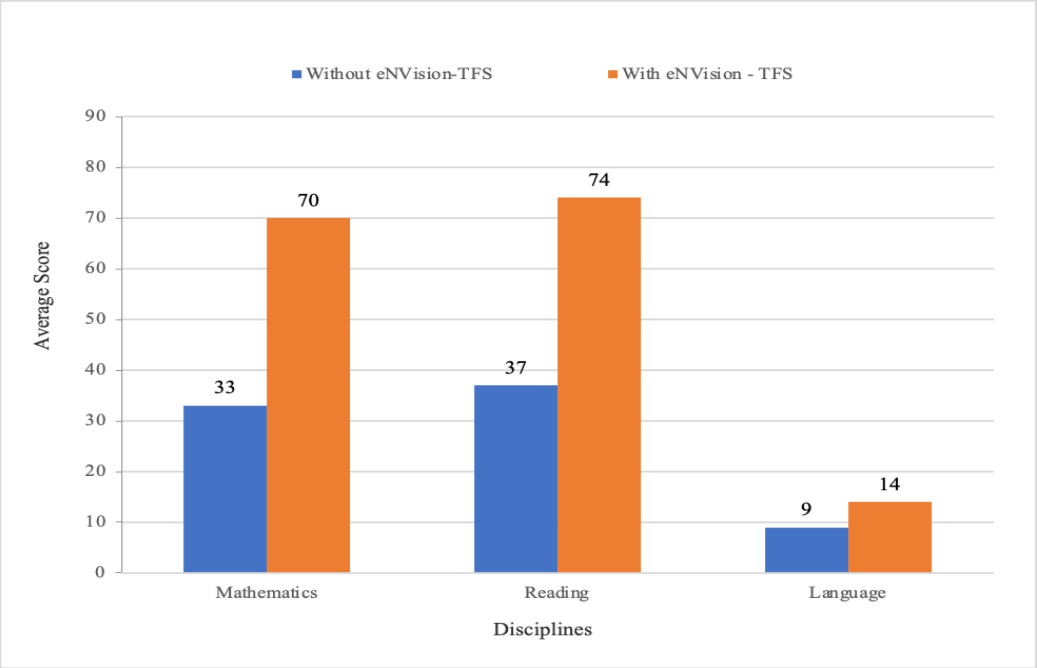
During weeks 12 and 13, the PSTs implemented the inquiry-based lesson plan using the TFS culturally relevant pedagogy and the BSCS 5E Learning Model (Bybee, et al., 2006) over nine consecutive days in seven classrooms with 25 underserved diverse students and one veteran teacher. During weeks 12 and 13 daily, each PST submitted a daily reflection that was evaluated by both authors to address PST concerns before the next teaching day. The final data source was

a revised exit survey completed anonymously by each PST to identify specific attributes of each university professor and information to inform revisions to this PDS collaboration.

Project Analysis and Findings

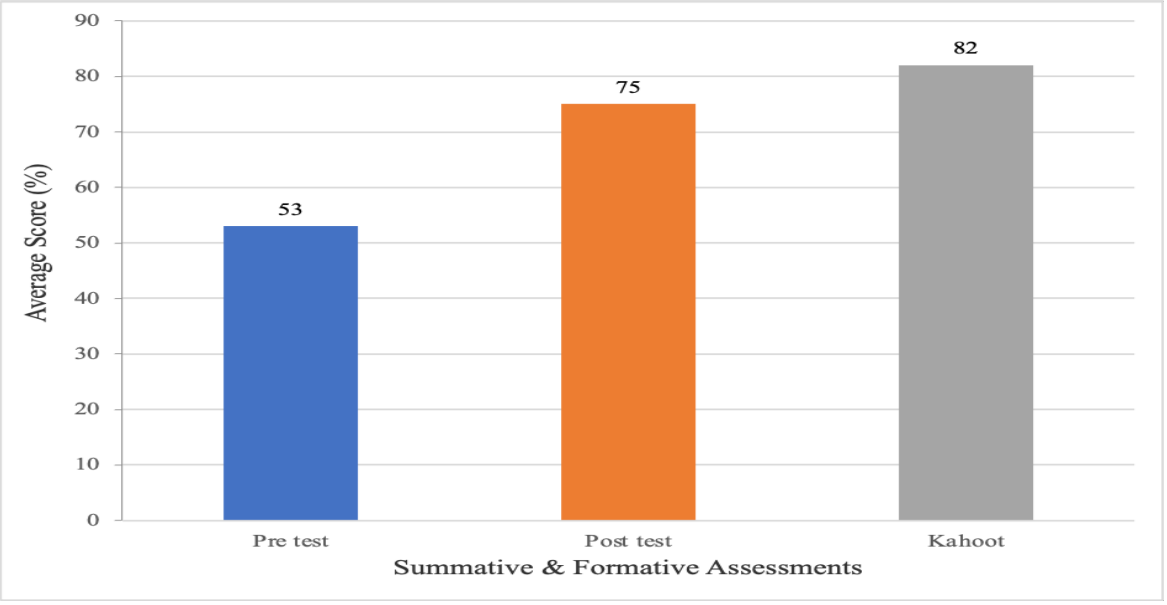
The summative assessments were the pre/post assessments administered on day one and day nine during the science teaching; and the Northwest Evaluation Association (NWEA) standardized assessments (Winter, 2020). The NWEA assessments compared the outcomes of the TFS-eNVision participants to the non-TFS-eNVision participants at the PDS site (see Figure 2).

Figure 2
TFS-eNVision Student NWEA RIT Total Growth Scores –Winter - 2020 Summative Assessment



The daily formative assessments were hands-on, minds-on activities, Kahoot questions and information recorded in the student's science notebook (see Figure 1).

Figure 1
TFS-eNVision Student Science Formative & Summative Assessments Scores



No control data was available for the PDS students that did not participate in the TFS-eNVision program. The rationale for all these assessments was to document science understanding and learning for all TFS-eNVision PSTs and PDS K-4 students. Finally, the principal and university faculty shared reflections to express the benefits and impact of this intense immersive experience on the PSTs compared to a traditional practicum in a non-PDS school that normally included less than 20 contact hours for the PSTs.

The preliminary results are the average NWEA standardized test results for the classrooms (n=7) that participated in the TFS-eNVision program compared to the control, the classrooms (n=5) that did not participate in the program (see Table 3).

Table 3
PDS Student Results from the NWEA RIT Total Growth Scores, Winter 2020

Conditions	*n*	Mathematics	Reading	Language
Control group	5	33	37	9
TFS-eNVision Classrooms	7	70	74	14

Note. The n indicates the number of classrooms, not the number of individual students. The values are percentages.

For mathematics and reading, the students who participated in the TFS-eNVision program total growth score was twice the total growth score as the control group. The language total growth score was one and a half times higher than the control group. The preliminary results are averages

from the formative and summative assessments implemented with the PDS K-4 students during the science lessons (see Table 4).

Table 4
PDS Student Science Results from Formative and Summative Teacher-Made Assessments

Grade levels	*n*	Pretest Average	Posttest Average	Kahoot Average Score
Kindergarten	22	69%	94%	88%
First	48	46%	85%	67%
Second	24	62%	60%	73%
Third	25	46%	80%	82%
Fourth	24	50%	84%	74%
TFS-eNVision Program	143	55%	81%	77%

Note. Third grade information is only for one class due to missing data from one of the PST coteaching teams.

These assessments were created and delivered through the online platform Kahoot and in hard copies of each pre and post assessment. Most of the grade levels improved from the pretest to the posttest except the second graders. The kindergarteners and second graders pretest averages were higher than the program average of 55%. The second and third graders posttest averages were less than the program average of 81%. The first, second, fourth grade Kahoot averages were lower than the program average of 77%.

Table 5 shows the PSTs' daily reflections during science instruction. The reflections were extrapolated from two students from three different days: day one, five and eight during the nine consecutive days the student's taught science. These are examples from two students' efficacious statements reported in the reflective journal and were representative comments from most of the students in the program.

Table 5
Pre-Service Teachers (PSTs) Beliefs Regarding Science Education Impact

Student	Grade level Taught	Practicum Day	Reflections
A	K	1	"After today I am feeling confident in my test giving skills …I noticed that the students really enjoyed the Kahoot, so we are thinking of adding our probing questions to our Kahoot as well."
		5	"After today I am feeling more confident in leading instruction and being the main teacher in the classroom. Today I observed that the students really enjoy hands on activities and crafts. Today I observed that the students are engaged when they know what is going on in the class."
		8	"I observed almost all of the students being able to answer the post-test questions right away."

B	3rd	1	"The students confidently filled out the left side of the plant booklet. They knew all the parts because we reviewed them yesterday. The students loved the yoga because it gave them a chance to sit and reflect on what they just learned."
		5	"During day five of practicum, the students reviewed the information they discovered from the videos on Schoology (about the three types of plants). To do so, I asked guiding questions/discussion starters and when the kids responded, Paige wrote down what they said. They then filled out what she wrote on their individual Venn diagrams. After this, the students answered the day's probing questions. Next, we explained that we were going to do virtual reality; the students were SO excited and happy when this was announced. Then, we split them off into groups of three. Each group went into a different area of the room and took turns looking at the three different environments of the C3, C4, and CAM plants. Lastly, the students took a Kahoot. To transition into what Mrs. Barbosa was doing next…"
		8	"During day 8 of practicum, the students took a Kahoot that asked questions about what should be included in their podcast. Next, the students finished up their scripts they started the day previously. Then, the students filmed/recorded their podcast. The students absolutely LOVED this assignment. They were super excited when they found out that they could watch their peers' podcasts and leave comments on the discussion board!"

Table 6 contains reflections from the same two PSTs daily reflections during science instruction.

Table 6
Pre-Service Teachers (PSTs) Benefits Reported Regarding Science Education Impact

Student	Grade Level Taught	Day	Reflections
A	K	1	"In my classes I have heard about classroom management but until this course I have not been able to actually see it in process. I was able to see how management can be used in a classroom and how it differs for all students. I feel like this course gives future teachers the time and opportunity to have practice teaching before student teaching starts. How a morning in a kindergarten classroom looks like. I have taken kindergarten classes that talk about mornings, but I did not have the opportunity to see this in use."
		5	"I have been able to actually work hands-on with students instead of just watching videos and hearing about it in my classes."

		8	"This course has given me the opportunity to create a whole unit lesson plan and then implement it in a real classroom. This has helped me gain confidence in teaching and leading a class. Through this experience I have been able to interact with students in the grade level I want to teach when I graduate."
B	3	1	"Creating a cross-disciplinary lesson with writing and science is easier than it seems. Science is very underrated and needs to be recognized."
		5	"Classroom management techniques such as call and responses are vital when teaching."
		8	""Teachers need to provide challenging projects to their students."

The biggest impact of the TFS-eNVision program for this PDS school is the opportunity to serve in a low-achieving school with underserved diverse students during the school day that normally do not receive authentic hands-on, minds-on science instruction (IDOE, 2021). An analysis by the authors found that the increased time the PSTs received in the school engaged with students increased the PSTs confidence and competency to teach in the future, suggesting that future practicums in non-PDS sites should include an increase of at least ten hours in the practicum before they begin teaching science to ensure the PSTs build a relationship with the practicum students and teachers. Additionally, the findings support an immersive experience such as TFS-eNVision can produce educators who are culturally relevantly and responsive. The value of immersing PSTs in their school community while they participate in a multidisciplinary course block is unmatched by traditional approaches to field placements. Providing such an opportunity should be a priority in education programs.

Discussion

The TFS-eNVision school-university collaboration partnership with this PDS seems to impact all the participants in this collaboration. The summative assessments administered to the TFS-eNVision elementary students both revealed an increase in all three areas of the NWEA RIT Total Growth Scores Winter 2020 results, with the greatest increase in mathematics. The second formative assessment for the elementary students revealed an increase in all grade levels except second grade. The formative assessments designed in the TFS-eNVision program were hands-on, minds-on inquiry activities which allowed the PDS students to participate in science. The outcome demonstrated the PDS students' increase in science content knowledge and understanding. These results support Vygotsky (1978) theory of teaching and learning in the students' ZPD and sociocultural philosophies while using inquiry-based teaching.

The TFS-eNVision program impact on the PSTs included: 1) training and continued growth by providing authentic teaching experiences; and 2) extended time in the school with the students and mentor teachers which benefitted all participants in the TFS-eNVision program. This was revealed in the PDS student's formative and summative assessment scores; and the progression of growth in the PSTs as revealed in the sample daily science reflections. Reflections during the

semester indicated growth and perceptions from most of the PSTs which was supported by the quantitative data collected from the preliminary science pre/post assessments and NWEA RIT Total Growth Scores Winter 2020 standardized assessment growth.

The reflections from PSTs, university faculty and the PDS principal all revealed a positive impact from participating in the TFS-eNVision project in a PDS site. Rethinking the structure of teacher preparation programs is critical if the US is going to produce competent and confident White female teachers to teach students from diverse cultural/ethnic backgrounds with a reduction in bias, ethnic stereotyping, cultural ethnocentrism, fears and/or anxiety. Pedagogical designs (using culturally relevant teaching, inquiry, coteaching and the BSCS 5E Learning Model) are anticipated to aid in reducing the theory-practice gap that initial teacher education (ITE) programs report as a problem in teacher education prep programs (Feiman-Nemser, 2001; Veeman, 1984; Bates, 2002; Connelly & Clandinin, 1995; DEST, 2002; Ethell, 1997; Kalantzis, Cope, & Harvey, 2003; Levine, 2006; Louden et al., 2006; C. S. Marshall, 1999; Murray, Nuttall, & Mitchell, 2008; Nelson, 2005; Smith, 2000, 2008; Sumara & Luce-Kapler, 1996). This innovative structure can possibly influence their implementation of science lesson plans during student teaching or in their regular classrooms.

The PSTs demonstrated Gay's (2010 and 2018) 'caring in action' and Ladson-Billings (2006) culturally relevant teaching all semester with the PDS students. Adoption of these philosophies and suggested pedagogy will also help reduce the PSTs fears to teach their future students. Murphy et al. (2013) reports co-teaching, co-planning and co-reflection helps co-teachers from feeling isolated in teaching which is another attribute the PSTs reported after participating in this program. Martin (2009) beliefs around co-teaching was also supported because the PSTs did see an increase in their quality of teaching science, which led to an increase in the PDS student academic achievement and science learning. The PSTs also expressed a greater enjoyment of science and development of a positive and sustainable teaching approaches. The PDS students results from the formative and summative assessments from this experience, although preliminary, seems to show their teachers, PSTs, and school principal that participation in the TFS-eNVision program did impact their ability to learn and understand science. Their participation seems to influence how the TFS-eNVision PDS participants performed on their standardized NWEA RIT Total Growth Scores, Winter 2020 (see Figure 2).

Suggestions and Educational Implications

TFS-eNVision program embedded in a PDS school in the Midwest is an excellent model to use in other low performing schools in this area. The 14-week practicum experience exposed the PSTs to what is happening in a PDS school from day to day. Requiring the PSTs to teach science in co-teaching teams with another PST and veteran teacher, using the BSCS 5E Learning Model, reduced the White female PSTs' bias, assumptions, and fears to teach diverse underserved groups. Moore (2008a); & Rodriguez (1998) indicated that unless PSTs address these deficit notions, they will not become the teachers who promote culturally relevant teaching, which is critical when serving diverse underserved groups. Zapata (2013) calls it a paradigm shift which involves a transformation, a metamorphosis that yields PSTs serving as change agents in teacher education.

Our preliminary data also indicated science education preparation programs that are tailored to address White female PSTs' bias, assumptions, and fears to teach diverse underserved groups can provide opportunities in the classroom and in a practicum before student teaching to articulate and confront their beliefs and biases and/or misconceptions. Educational programs need to

undergird these PSTs in their preparation, creating White female teachers that are competent and know how to teach in the student's ZPD that uses desirable and equitable science pedagogy.

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