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Table of Contents

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REQUEST FOR MANUSCRIPTS

CITE

Critical Issues in Teacher Education

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Experiential and Interdisciplinary Teaching and Learning through Archaeological Exploration

by

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Abstract

This paper explores the unique educational opportunities presented by archaeological excavations that enable hands-on archaeological research intertwined with interdisciplinary learning. Highlighting the experiences from the SOAN 230 - Archaeological Field Studies course conducted in Fall 2023 and 2024, the authors detail how students from various disciplines engaged directly in the excavation process, applying and developing skills not typically taught in traditional curricula. The integration of experiential learning theory alongside interdisciplinary collaboration provided students with the chance to enact theories studied in the classroom while simultaneously cultivating critical thinking, problem-solving, and communication skills. The findings illustrate the potential of on-campus archaeological projects to bridge disciplinary boundaries and teach interdisciplinary skills.

While opportunities to dig a mammoth or mastodon are rare to find on campuses, university campuses often have archaeological sites of one sort or another that can provide unique opportunities for students to learn interdisciplinary skills. Excavations of these sites by non-archaeology majors for General Education credit allow students to experience an archaeological excavation, but more importantly, to bring their skills from their other disciplines and apply them to a unique project (Cobbi, 2022; Cobb & Croucher 2020). The immediate application of classroom theories in the field is a proven way to enhance skills, interest, and knowledge retention, and interdisciplinary skills are crucial in today's complex world where problems require the application of ideas and skills from multiple disciplines. In addition, students are likely to work in several different fields during their lifetimes unrelated to their major. Unfortunately, universities rarely teach transdisciplinary skills, and therefore students are not taught to cross disciplinary boundaries and apply their knowledge and skills from their majors to different contexts (Turner et al, 2022).

Principia College is a small Liberal Arts college located alongside the Mississippi river near St Louis. It was founded in the 1930s and has twenty-two majors in the Arts, Humanities, Social Sciences and Sciences. Principia has long emphasized experiential education due to its philosophy of demonstrating concepts rather than just believing in them. There is a solar car project that helps students demonstrate concepts in engineering, computer science and physics, and several other projects in biology, politics, art, and humanities that have been hugely popular and even successful in nationwide competitions.

With a decrease in anthropology majors and a need to expand our reach and relevance to the broader student population, the Archaeological Field Studies class was seen as a way to teach and apply several skills taught by numerous other majors at the college. I was a member of the Multidisciplinary Department for ten years and taught several interdisciplinary courses to train students in transdisciplinary borrowing. These courses encouraged students to draw on their knowledge from other majors for class projects. Archaeology has been one of these, and I have conducted a few excavations on campus over the years. One was of the first European settlement in the area, and another was of a multi-era Indigenous American Settlement. Both have helped me to develop an Archaeological Field Studies course that integrates excavation into the classroom.

The recent discovery of a mastodon on the college campus in 2022 opened the possibility of using archaeology to teach and apply interdisciplinary skills from numerous majors in a more comprehensive way. But the Mastodon was not the first megafauna to be discovered at Principia College. In 1999 "Benny," an almost intact woolly mammoth, was discovered. This established the campus's reputation for significant paleontological finds. The discovery of Benny, located near the Rackham dormitory at the center of campus, allowed a long-term, in-depth study that spanned 12 years. Students from a variety of fields—ranging from anthropology to engineering—gained hands-on experience and applied their skills. In keeping with this tradition, the 2023/24 excavation of a Mastodon, also on campus, continues to provide interdisciplinary educational opportunities while allowing students to directly engage with the processes of archaeological research and preservation.

Experiential Teaching and Learning

Experiential education provides many benefits for traditional teachers wishing to connect students with content, illustrate theories with examples, and promote critical thinking. However, it can also emphasize real-world applications of skills, enhancing engagement, retention, and understanding beyond conventional lectures. Research shows that experiential learning accelerates student learning by linking concepts to personal experiences (Hattie, 2023). Kolb (2015) asserts that active participation fosters deeper comprehension and ownership of education by applying theoretical concepts in practical contexts, making learning enjoyable and reinforcing the relevance of knowledge to real-life situations.

Archaeological Excavation is often associated with fostering appreciation of cultural heritage, stewardship, and support for preservation of historical sites, but excavations provide so much more. Archaeology is especially useful for teaching a range of concepts and skills, in addition to an appreciation of heritage. Mathematics, technology skills, and scientific recording skills are taught and practiced in the process of recording artefacts, bones, environmental data, and their locations (Thomas, 2023). Critical thinking and analytical thinking skills are commonly learnt while problem solving and reviewing interpretations as the excavation progresses (Cobb & Croucher 2020). Collaboration, communication, and interpersonal skills are learned while working in teams (Thomas, 2023; Arendt, 2013). However, there is a complexity to choreographing an experiential learning activity to connect ideas and skills with activities and maximize the learning experience.

Experiential Learning Theory (ELT) posits a four-stage process of experiential learning
(Kolb, 2015).

1. The first stage is directly engaging in an experience, which serves as the foundation for learning.
2. In the second stage, learners reflect on their experiences, considering what worked, what did not, and the meaning of the experience.
3. The third stage requires learners to develop theories or concepts based on their reflections, abstracting and generalizing from the concrete experience.

4. In the final stage, learners apply their newly acquired knowledge to real-world situations, testing their theories in practice.

This cyclical process allows for continual growth and adaptation, ensuring that learning is relevant and progressive (Kolb & Kolb, 2017).

In addition to the importance of experiential learning is the importance of Interdisciplinary Studies. For the past twenty years, major funding agencies, scientific organizations, and major educational institutions have advocated the need for interdisciplinary studies (Baskin, 2012). Because of the complexity of society, nature and people, because students need to be educated for a range of future careers (not just one) and because the world itself and workplaces are changing, we need to be able to apply skills and knowledge from multiple disciplines to complex and evolving problems that cut across disciplines (Repko et al, 2019).

For example, to understand and address climate change, one needs to use a range of different disciplines ranging from sociology, physics, ecology, meteorology, politics to mass communication. The ability to research other disciplines, identify relevant theory and methodologies that might help, become familiar with them, summarize and apply them to problems in another discipline requires training and practice. Archaeology is well placed to offer this training, as it has always borrowed theory, methodology and techniques from other disciplines.

Archaeology is a naturally interdisciplinary subject since at its core is the search for clues to reconstruct past worlds. To reconstruct entire past worlds, we need all the disciplines that seek to understand today's world. Archaeologists have sought multiple sciences to extract data about the past from the earth, including pollen analysis, snail analysis, zoology, forensics, radiocarbon dating, isotope analysis, soil science, geology and many others from physics, chemistry and biology (Cobb & Croucher 2020; Bartoy 2012). To piece together data from those sciences to reconstruct what the physical, social, political, and religious world was like not only demands the physical sciences, but also the social sciences and humanities. Mathematics and computer science help to analyze and model data, Anthropology and Sociology study humans and their behavior, History offers background information about civilizations, events and practices, Art History helps with the analysis of artifacts, Linguistics helps interpret written and semiotic languages, religion and philosophy help to understand the deeper ontologies driving behavior (Thomas, 2023).

During an undergraduate or graduate degree in archaeology, students are exposed to a number of these disciplines and taught interdisciplinary skills through projects that apply theories and methodologies from them. This process is very similar to the latest theory on attaining interdisciplinary skills.

In their book *Introduction to Interdisciplinary Studies*, Repko, Szostak, and Buchberger (2019) write that there are five key ways that interdisciplinary application skills are developed and should be taught.

1. The most important way to teach interdisciplinary applications is through projects that require students to solve real-world problems using knowledge from multiple disciplines.
2. The second important requirement is to foster an environment where students from different backgrounds and fields work together. Group work and peer teaching can enhance learning and understanding of interdisciplinary connections.
3. The third requirement is to design a curriculum that intentionally blends subjects, such as combining sciences with humanities to explore complex

societal issues, providing case studies to illustrate how other interdisciplinary solutions were arrived at.

4. The fourth requirement is to teach systems and contextual thinking, or the ability to break a problem down into its constituent parts and influences and view a subject from a broader perspective than merely a disciplinary one.
5. The fifth key to solidifying interdisciplinary skills is assessment and reflection. Encouraging students to reflect on their interdisciplinary experiences and the skills they have developed is important to allow them to recognize them and apply them elsewhere.

While this process is taught unconsciously in archaeology degrees over the course of four years, it is possible to telescope this process into one course taught in one semester. Even better, it is possible to use such a course as a general education requirement to consciously teach non-archaeologists interdisciplinary application skills.

Setting up the Archaeological Field Studies Course

While an archaeological excavation provides many opportunities, excavating during class times presents a unique set of challenges that require careful planning and coordination.

Three of the main challenges were the limited amount of time to excavate, limited personnel and facilities. The Mastodon was excavated purely during a weekly six-hour lab course - over 16 weeks of the Fall semester (the equivalent of two solid weeks per year). There were only eleven students, and I was the only supervisor. A normal excavation for an Archaeological Field School usually takes place over five solid weeks of the summer vacation with several student and faculty supervisors to coordinate the operation. Summer field schools allow careful, but time-consuming, recording of artefact and bone locations as well as analysis of artefacts and environmental data. They also produce a lot of paperwork - finds and context sheets that must be transferred to a computer database.

The third problem was that the site was left for four days over the weekend in-between classes during difficult autumn conditions, exposing the bones to the elements and unscrupulous visitors. The challenge of excavating during class times in the semester, while I had to teach two other courses, required finding a variety of solutions to enable us to excavate and analyze the finds effectively.

The first solution was to find an old portacabin and convert it into an on-site classroom, site office, and conservation laboratory. This enabled classes to be taught on-site followed by experiential interdisciplinary application of theory, knowledge, and skills immediately afterwards without lengthy trips between the classroom and the site. I was also able to persuade the college to erect a tarp structure over the site with cameras. This solved the problem of working outside in autumn conditions and protected newly uncovered bones from the elements and visitors, while having a place to teach and store the equipment and bones.

To solve the problem with having to run the portable conservation lab while supervising the excavation, I applied for funding for a talented student intern from the Chemistry department to supervise the laboratory while I was on site. This gave her good experience at applying her chemistry skills and running a lab.

The most pressing demand was to make the excavation run efficiently enough so that we could spend the maximum time excavating during class times. To cut back on the time spent recording data, maximize efficiency and increase accuracy, I turned to technology. I employed a wide array of technologies to facilitate excavation and documentation. This also allowed students to learn about various technologies and learn to apply technologies to real-world problems.

To ensure we dug in the right spot for the second season, I invited the archaeologists from the University of Illinois to help us survey the site with Ground Penetrating Radar (GPR). This gave the students invaluable experience with GPR while enabling us to detect subsurface anomalies and where it was most profitable to dig.

Another investment was an iPad Pro. The iPad Pro has several apps that enable archaeological excavations to be streamlined. However, after researching and talking with several companies, I discovered that there were no apps for excavating Mastodons which involves a unique set of recording skills and measurements. Therefore, I found a free app (Clappia) that facilitates the creation of your own recording apps, and I developed an iPad app to allow for offline data entry and digital notetaking. This enabled the creation of artifact and context sheets, as well as photographs to be taken by the iPad that were all uploaded onto a central database as soon as a Wi-Fi signal is reached. This ensured that all findings were recorded accurately and automatically uploaded efficiently, without the use of paper or time-costly transferring of data which often results in problematic human errors.

The iPad Pro also had an app (Scaniverse) which allowed us to map the site in 3D. Scaniverse uses Photogrammetry and the iPad Pro's Lidar function to create a perfect 3D image of the site that can be loaded onto a database or website and used for analysis. This gave us an even better tool for analyzing the site than photography.

As the excavation progressed, students used trowels and skewers to carefully uncover the bones, ensuring that no damage was done to the fragile remains. However, each bone had to be located with the right coordinates within the site. This is another time-costly process, involving several measuring tapes, plumb bobs, and string, preventing work on the rest of the site until each measurement is done. Therefore, we used another technology, a total station pulse laser – used traditionally by architects and developers to survey landscapes. Using a Nikon 322 total station enabled us to log the GPS coordinates of each find precisely by firing a laser at the objects. This allowed us to ensure precise measurements and mapping of the bones, which were then all uploaded onto a Geographic Information System (GIS) for spatial analysis.

One of the things that I had not anticipated when we first discovered the mastodon was the level of public interest in the excavation. As soon as news of the discovery got out, I was interviewed by several newspapers, TV, and radio stations in the St Louis area, and even by Fox News and NPR. I realized that there would be large numbers of visitors to the site, and I had to find a way to disseminate the results and delegate speaking to the public while teaching and supervising the dig. Consequently, students were taught how to and graded on speaking to the public and the media, and I made it an assignment for them to create a website where information was regularly updated. Although other excavations might not attract as much publicity, there are often visitors to archaeological digs, and these can provide additional opportunities for students to learn communication skills.

We were fortunate that we found notes from the previous mammoth excavation at Principia in the college archives detailing the structure of the mammoth curriculum that had been developed over 12 years for Benny. This allowed me to structure the class so that I could teach subjects and skills in a chronological order that were needed to conduct an excavation of a mastodon (Rives-East & Lima 2013). From surveying the site to setting up the trench, to teaching site etiquette, excavation skills, formation theory, conservation skills, geology, mammoth and mastodon behavior, bone osteology, environmental data, systems thinking, interpretation etc. This was in line with key 3 and 4 of Repko et al's ways to teach interdisciplinary skills (2019), to design a curriculum that intentionally blends subjects from different disciplines and intentionally teaches systems thinking.

After each short class, the students were able to go to the site and apply the knowledge and skills they learned directly (key 2). This improved on traditional Archaeological Field Schools taught during the summer, because Field Schools are difficult environments to teach content and specific skill sets. Students usually learn the theory the semester before and have forgotten them by the summer. Teaching skills and theory immediately before surveying, excavating, recording etc. reduced the time needed to do those tasks because students were so focused and prepped, and it enabled them to apply and learn abstract concepts and skills much more effectively (Yemini et al, 2023).

With all the new technologies I introduced, there were several skills that I had to learn and teach that I did not have. I decided to take advantage of this challenge when I had students from a range of disciplines at the college – from engineering, to biology, chemistry, computer science, anthropology, history, mass communication, and studio art. In line with key 2 of Repko et al's ways to teach interdisciplinary skills (2019), I tasked several students to research and teach the other students various technologies that they had knowledge of, before the students then applied the skills themselves (Jacobs & Alcock, 2017).

The four engineers and computer scientists helped me figure out and teach the Total Station technology to the students, and how to create and maintain a GIS database. The chemistry intern helped me to figure out the best process and chemicals for conserving the bones and then taught and supervised the other students. The biology major also researched and taught the students how to analyze mastodon bones. This applied the pedagogy of "learning by teaching," an important way for students to feel invested in an activity and learn the skill thoroughly (Duran, 2017).

In order for the students to practice the skills, I organized the tasks of the excavation, sifting, recording, and bone conservation into roles on a rotating schedule so that each week students would have a chance to practice each role, in a group of two, several times during the semester. For the more complex roles, I asked students from the previous week to teach the students at the beginning of the following week how to do them. I checked in later with them, but this delegated much of my work.

I then created an assignment for students to either create and maintain a website, write a conference paper, or create a conference poster about the dig. After lectures on how to create websites, conference papers and posters, the students were divided into three groups and worked on each project during and outside of class. The engineering and computer science students created a website with a time-lapse video of the dig, the 3D scans, photos, and the GIS database. The artists and Mass Communication major produced a conference poster about the dig and the philosophy and history majors who were good writers and speakers wrote a conference paper about the process. Students then presented their website, poster, and paper to the class with reflections about applying their knowledge and skills to the assignment.

To give the students experience at presenting at conferences, I took four of the students to the Midwest Archaeological Conference (MAC) in Milwaukee for three days. After working with the students for several days to polish their paper, PowerPoints, and poster, and practice their presentations, they took part in presenting them at the professional MAC conference with great success. This opportunity resulted in the students learning numerous other skills. They learned research and critical thinking skills, and to synthesize and analyze information. They learned communication, design, writing and public speaking skills, and learned how to present their findings clearly in a manner appropriate for a professional conference. And finally, they gained confidence and learned an enormous amount about academic culture. After the conference, all the students said that they would like to go on to graduate school, having seen academic life firsthand.

By working together in groups, teaching and applying skills from their majors to solve problems on the excavation, they saw the real-world benefits of those skills, as well as learning interdisciplinary application skills. Students were able to learn through teaching, practice, and group work (key 2) in all sorts of advantageous ways (Kolb & Kolb, 2017). While a high school or even college class might not be able to arrange for students to give conference papers, there are a range of venues that students could present in. Other archaeology classes of mine have given talks to a local historical society and a school.

Students also engaged in reflective practices, documenting their experiences and learning through daily journal entries. Apart from learning a basic archaeological practice, this reflective component allows students to connect classroom theories to their hands-on experiences, facilitating a deeper understanding of archaeological practices. Additionally, this process allows students to note areas of inquiry that require further exploration, fostering a mindset of continuous learning. This was in line with key five of Repko et al (2019) and stage 2 of Kolb's (2015) experiential learning process to reflect on their experiences.

Students were also able to reflect on their experiential and interdisciplinary learning through a mid-term and a final reflection paper. These short papers allowed students to reflect on their experiences and interdisciplinary applications, develop theories about their reflections and then be more awake to experiential and interdisciplinary learning throughout the rest of the semester in line with stage 2, 3 and 4 of Kolb's experiential learning process (2015).

In addition, students were assessed through periodic quizzes on the content and skills. These quizzes, and the two reflection assignments helped to reinforce content mastery and encourage metacognitive awareness of their interdisciplinary learning in line with key five of Repko et al's (2019) keys to interdisciplinary learning.

Results

The 2023 excavation season yielded several significant discoveries, including bones, fragments, teeth, and charcoal, from the mastodon. This has led to hypotheses about the mastodon's death. As we carefully excavated around the tusk using skewers and dental tools, students uncovered additional portions of the skull and an unusual set of circumstances at the end of the tusk. Not only is the end of the tusk blackened by an intense fire, the tip of the tusk also appears to have broken off and moved at an odd angle. This indicated some sort of fire at the tip of the tusk, confirmed by small bits of charcoal here and there around the tusk. Two pieces of broken polished chert that were found around the skull led us to first hypothesize that the mammoth was killed and butchered by humans. However, a radiocarbon date of 27,760 BP (+-60yrs) from a piece of the charcoal confirmed the tusk to be much older than any human settlement of the area.

These findings have allowed a hypothesis to be suggested about the mastodon's cause of death. A mastodon that was injured or dying from disease would have descended to a water source, as elephants do, at the foot of the bluff rather than the top. Therefore, it seems likely that it died a sudden death. Mastodons were formidable animals and did not have many predators either. It is possible that the mastodon was killed by another mastodon which sometimes occurred when males fought other males over females during the spring mating season. However, another hypothesis, which is currently favored, is that the blackened tip of the tusk and the distribution of charcoal all around the area resulted from a natural event, such as a lightning strike, which may have caused the death of the mastodon. It died near the top of the 200ft high bluffs which would have made the mastodon vulnerable in a storm. The end of the tusk appears to have broken off which may have resulted from the mastodon falling hard on the ground after being struck. Finally, the discovery of fragmented skull bones and other elements indicates that much of the skeleton had been disturbed, due to scavenging by animals.

Once we contacted the Illinois State Museum with our findings, they informed us that our mastodon was the oldest found in the Midwest by 10,000 years. An additional radiocarbon date of 26,061 (+-60yrs) confirmed the date. The earliest recorded mastodons recorded in the Midwest before now were 16,000 BP. It was exciting for the students to hear that their work has rewritten the paleontological history of the Midwest.

In reviewing students' midterm and end-of-semester reflections as part of course assessment, several patterns emerged that align with Kolb's experiential learning framework. Kolb’s four-stage criteria for experiential learning (Kolb, 2015), plus two criteria for interdisciplinary learning can be outlined as:

1. The first stage is directly engaging in an experience, which serves as the foundation for learning.
2. In the second stage, learners reflect on their experiences, considering what worked, what did not, and the meaning of the experience.
3. The third stage requires learners to develop theories or concepts based on their reflections, abstracting and generalizing from the concrete experience.
4. In the fourth stage, learners apply their newly acquired knowledge to real-world situations, testing their theories in practice.

The two additional criteria were:

5. In the fifth stage, students bring expertise from their home major studies to the experiential learning project
6. In the sixth stage, students carry forward lessons learned from the experience to enhance and enrich their learning in their disparate fields of study.

The following observations reflect the instructor's pedagogical impressions based on classroom interactions and assignment evaluations, rather than systematic analysis of student learning.

Concrete Experience and Reflection (Criteria 1 and 2). Throughout the semester, in discussions and their reflections, students frequently expressed strong engagement with hands-on learning. Most students began with prior conceptions of archaeology rooted in popular media but systematically developed more nuanced understandings through direct experience. Students frequently described a diverse range of hands-on activities – including surveying, excavation, artifact cleaning, and field documentation – that served as the foundation for deeper learning. Many noted that the tactile, embodied nature of fieldwork enhanced retention and engagement compared to classroom-only instruction. A notable shift in dispositions emerged: students reported increased patience, curiosity, and appreciation for discovery-based learning. Several expressed that hands-on engagement transformed their relationship to academic content, making material "cooler" and more relevant than abstract coursework. Students also articulated an expanded understanding of learning itself – recognizing that unexpected discoveries, rather than disrupting the learning process, often enriched and redirected it productively.

Theory Development and Application (Criteria 3 and 4). Students demonstrated progression toward the third and fourth stages of experiential learning by connecting classroom theory to field observations. Most reflected on how classroom lessons took on new meaning when encountered in situ – for example, linking taxonomy instruction to the moment of discovery in the field. Students noted that the transition from abstract classroom concepts to applied field observation was particularly valuable, with some expressing that this integration of theory and practice provided experiences that even advanced practitioners (such as graduate students encountered at professional conferences) viewed as noteworthy. This suggests students were effectively developing conceptual frameworks grounded in both intellectual understanding and concrete observation.

Interdisciplinary Integration (Criteria 5). Students across multiple disciplines successfully brought expertise from their home majors to enhance the project. Those with design backgrounds leveraged graphic design and web development skills to create professional conference materials and site documentation. Art students applied drawing and visualization skills to create scaled site maps and illustrations. Computer science students developed functional websites and digital tools. Rather than viewing these contributions as tangential, students recognized them as meaningful applications of disciplinary expertise within an archaeological context, indicating strong recognition of how their specialized knowledge enriched collaborative, interdisciplinary work.

Transfer of Learning (Criteria 6). Students articulated clear pathways for transferring experiential learning to future academic and professional contexts. Many identified specific skills with broad applicability – conference presentation writing, team collaboration, environmental mapping, and analytical frameworks from social theory – that they anticipated using in their major fields and beyond. Several explicitly connected field-based learning to coursework in related disciplines (such as sociology or world history), suggesting that the experiential project served as an integrative hub that enhanced learning across their academic programs. Students demonstrated awareness that the professional and collaborative dimensions of the project – including conference participation and peer teamwork – represent transferable competencies valuable across disciplines and career trajectories.

It was clear from students' comments and discussions that they came away with an appreciation of the synergy that is possible when individuals possessing different skills, perspectives, and backgrounds come together in a team and apply their training and talents to a multi-faceted scientific field study. Students came to the experiential project with skills from disciplines such as graphic design, computer science, art, history, and sociology, but the course catalyzed or stimulated their academic curiosities and elevated their awareness of the interconnectedness of disciplines previously thought to be unrelated.

Educational Impact

The excavation of the Mastodon on the Principia College campus has served not only as a significant archaeological endeavor but also as an impactful case study in modern educational theory. Excavation epitomizes the tenets of experiential learning—a pedagogical approach that prioritizes learning through direct experience. According to David Kolb's Experiential Learning Theory, learning is most effective when it is grounded in real-world experiences, allowing students to engage directly with the material they are studying (Kolb & Kolb, 2017). This theory posits that students learn best when they can reflect on their experiences, conceptualize what they learned, and apply that knowledge in new situations.

In the context of the excavation, students were not merely passive recipients of information. Instead, they were active participants engaged in researching, teaching, and practicing various tasks—ranging from carefully excavating and conserving bones to documenting data using advanced digital technologies like total stations and GIS. Each task required critical thinking, problem-solving, and the application of theoretical concepts learned in the classroom. Furthermore, through daily journal entries, students engaged in reflective practices that allowed them to internalize their experiences and connect them to broader theoretical and interdisciplinary contexts. This reflection heightened awareness of their learning processes and fostered critical thinking skills, enhancing their educational journey.

The collaborative nature of the excavation project emphasized the importance of interdisciplinary learning. Students from diverse fields—including engineering, anthropology, journalism, biology, and chemistry—collaborated to tackle the complex challenges posed by the excavation (Freeman et al, 2014). This approach aligns with current educational theories advocating for research and teaching that bridges traditional disciplinary boundaries to foster a holistic understanding of complex topics (Prasad, 2024). By encouraging students to draw on knowledge and skills from various domains to solve real-world problems on the site, the excavation provided a rich context for developing crucial interdisciplinary skills. This cross-disciplinary collaboration not only enriched the excavation process but also deepened the students' appreciation for how their skills and knowledge could be applied in complementary ways.

The use of modern technology in the excavation process represents a critical component of the educational impact. As technology continues to change the landscape of education and research, its integration into academic curricula is vital for preparing students for the future job market and enhancing learning outcomes (Sung & Chang, 2015). Using tools such as ground-penetrating radar, iPads for real-time data entry, and total station laser survey equipment, students gained firsthand experience with cutting-edge technology that is increasingly employed in archaeological research. This exposure not only enabled them to efficiently document their findings but also provided practical training that is highly relevant to contemporary archaeological practices and many other jobs. The training students received in utilizing these technologies serves to cultivate valuable competencies, such as data analysis, mapping, and digital communication, which are essential skills in today's labor market (Turner et al 2022). Moreover, students were encouraged to innovate, research and teach technology to others, demonstrating initiative and adaptability—traits that are increasingly important in professional environments.

Another significant outcome of this excavation is the opportunity for students to engage with the wider community, both local and academic. With over one hundred visitors attending the site during excavation sessions, students took on the role of educators by explaining archaeological processes to laypersons. By speaking to radio, TV and newspaper reporters and presenting the dig to professional archaeologists at a conference, they learned how to present findings in several different settings. This experience not only developed their public speaking and communication skills but also fostered a sense of connection with the broader community. Research indicates that effective communication is a crucial interdisciplinary skill for job success and professional advancement (Repko et al, 2019). By discussing complex ideas in an accessible manner, students learned to distill intricate scientific concepts into clear and engaging narratives, an invaluable ability that extends beyond academic settings.

Conclusion

The excavation of the mastodon at Principia College has provided a rare and enriching educational experience for students at Principia College. By bridging the gap between theory and practice, students' understanding of archaeology has been enriched. Through interdisciplinary collaboration, experiential learning, the application of advanced technology, and community engagement, students have gained invaluable hands-on experience that directly connects classroom learning to practical archaeological research. Yet even more than this, it has given them transdisciplinary and other future-ready skills that have prepared them to face the complex, multifaceted challenges of the contemporary world and workplace.

Archaeology as a multidisciplinary field has the potential to help other universities to apply and develop many skills from other disciplines in a fun and collaborative venture. While other colleges might not have a mastodon to excavate on their college campus, it is quite possible that they have other types of archaeological sites that pose interesting research questions that can be answered in a similar collaborative way.

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Effects of Face-to-Face and Virtual Learning Environments on Low-SES African American Ninth-Grade Students' Reading Achievement

by
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Abstract
Many African American students have unequal access to educational opportunities, and it is questionable whether an online learning curriculum widens the reading achievement gap for this population or causes students to perform equally as poorly. The purpose of this study is to determine whether there is a significant difference in the reading performance of African American students of low socioeconomic status (SES) who receive virtual reading instruction compared to those who receive traditional face-to-face instruction in reading. This article will perform a quantitative analysis detailing the reading achievement scores of ninth-grade African American low-SES students in both virtual and traditional environments. Archived student reading performance data from the 2018–2019 school year were retrieved from the school district comprising one virtual and one traditional face-to-face high school campus with similar student demographics. The data included both State of Texas Assessment of Academic Readiness (STAAR) EOC and Renaissance Learning BOY/EOY percentile ranks for ninth-grade students. Results indicated that African American students who took classes in a virtual environment did not obtain reading scores that were significantly different from those in face-to-face classes. There was no significant effect of learning environment on the analyzed reading achievement scores for the students in this study. Educational leaders may find the study informative, as it may guide decision makers to make positive changes in the reading curriculum for African American low-SES high school students.

The rise of virtual learning has reshaped the educational landscape, particularly following the global COVID nineteen pandemic. In spring 2020, all students in the United States were moved online, and the U.S. Census Bureau (2020) reported that most households with school aged children participated in some form of distance learning. Even before the pandemic, enrollment in online courses had steadily increased for economic, personal, and academic reasons. More than six million Americans were enrolled in online education programs by 2015, reflecting ongoing growth in digital learning options (National Center for Education Statistics and Snyder, 2016).

A central question remains regarding how the learning environment influences literacy development when students transition into secondary school. Literacy development continues beyond elementary grades, and adolescents face increasing academic demands that can heighten existing inequities. African American students often contend with systemic barriers and long-standing opportunity gaps that influence their reading performance (Goldenberg, 2014). National data have shown that African American eighth graders score significantly lower in reading than their peers, underscoring persistent disparities (National Center for Education Statistics and Snyder, 2019).

This study examined whether the type of instructional environment, virtual or face to face, was associated with differences in reading achievement for African American ninth grade students of low socioeconomic status. Specifically, the study compared standardized reading outcomes across the two settings and explored whether the virtual environment presented benefits or challenges for this population of learners. Understanding how instructional delivery affects reading achievement is important as schools continue to integrate virtual and hybrid models into the high school experience.

Literature Review

The reading achievement gap has been a documented concern since the civil rights era. The Coleman Report (Coleman and National Center for Education Statistics, 1966), based on data from more than four thousand schools, revealed that students from ethnic minority backgrounds, particularly African American students, scored lower in reading at every grade level compared to White students. These disparities widened as students progressed into secondary grades, reflecting the influence of poverty, community conditions, and limited access to educational resources.

Socioeconomic status continues to be one of the strongest predictors of academic performance. Berk (2010) found that students from low SES backgrounds face widening achievement gaps as they advance through school. National data show that African American secondary students consistently score below their peers in reading, contributing to persistent differences in standardized test outcomes, grade point averages, graduation rates, and college access (National Center for Education Statistics, 2013; National Research Council, 2004).

These gaps are not rooted in students' ability or ethnicity. Singham (2003) emphasized that no inherent attribute of race determines academic potential. Instead, structural inequities such as school funding patterns, access to qualified teachers, and culturally relevant instruction play meaningful roles in shaping reading achievement.

Many students struggle in traditional classrooms, leading schools to explore virtual learning as an alternative method of instruction. The International Association for K through twelve Online Learning (2012) defined online learning as instruction delivered through internet-based platforms. In several districts it now supplements or replaces face-to-face instruction and provides new opportunities for students who may not thrive in conventional environments.

Virtual learning presents meaningful advantages. It can reduce absenteeism, remove transportation barriers, expand academic offerings, and provide flexibility for students who need personalized pacing. Powell and colleagues (2015) noted that online learning increases access to diverse instructional options and can support students who are disengaged or at risk of not graduating. Research has also explored the relationship between reading ability and success in online courses. Cook Gumperz (2006) found a positive relationship, although the effect size was small.

Despite its benefits, virtual learning also introduces challenges. Many students experience greater difficulty staying focused online compared to face-to-face settings (Pfost et al., 2013). In virtual environments teachers must compete with additional distractions such as television, video games, and household activity. Success online requires organization, self discipline, and consistent engagement, traits not always observed among struggling readers or students who have experienced longstanding achievement gaps (Travers, 2016).

Given the expansion of virtual learning in the United States, which saw more than two million K–12 students enrolled in digital programs by 2017 (Brodersen and Melluzzo, 2017), understanding its impact on reading achievement is essential. If virtual learning does not adequately support students who have historically struggled in literacy, schools risk widening existing achievement gaps. Identifying how the virtual environment influences reading performance for African American low SES high school students remains an important area of investigation.

Materials and Methods

This study examined whether there was a significant difference in the reading performance of African American low SES ninth grade students who received virtual reading instruction compared to those who received traditional face to face instruction. Prior research has shown that learning environment can influence student outcomes in meaningful ways, which supports the need to explore these differences (Deshler and Hock, 2007).

Data included Renaissance Learning reading percentile ranks and State of Texas Assessment of Academic Readiness End of Course English I scale scores from the 2018 through 2019 academic year. Scores came from one large Texas school district that operated both a traditional high school campus and a virtual high school campus with similar demographic profiles. Eligible participants were African American students identified as low SES based on free or reduced lunch status and who had available assessment data at all required testing points.

A group comparison quantitative design was used. Because the study relied on archival data, an ex post facto approach was appropriate. A nonrandom convenience sample was drawn from district provided records. Independent samples t tests and nonparametric analyses were used to examine differences between groups, and a significance level of .05 was applied. Data were requested and approved through the school district's Institutional Review Board, and the district provided the researcher with a secure password protected file for analysis.

Results

The results of the study examined differences in reading performance between students who received virtual instruction and those who received traditional face to face instruction. Independent samples t tests were conducted to compare Renaissance Learning percentile ranks and STAAR English I scale scores. The analyses showed no statistically significant differences between the groups at the .05 level. Although the virtual learning group showed slightly higher mean percentile ranks, the difference was not large enough to be considered significant. These findings suggest that for this sample of African American low socioeconomic status ninth grade students, the type of instructional environment did not produce meaningful differences in standardized reading outcomes.

Table 1. STAAR EOC Reading Scale Scores by Year and by Campus Type

Measure	Campus Type	Mean	Std. Deviation	N
STAAR Rd Scale Score	2 (F2F)	1670.35	159.749	145
	100 (Virtual)	1689.98	195.804	47
	Total	1675.16	168.953	192
EOC Scale Score	2 (F2F)	4047.11	684.380	145
	100 (Virtual)	4124.28	610.734	47
	Total	4066.00	666.378	192

Discussion

The findings show that virtual learning did not negatively influence reading achievement for the ninth-grade African American students in this study. On the standardized assessment, students performed similarly across instructional settings, suggesting that when prior achievement is considered, the delivery format alone did not create large differences in outcomes. This aligns with research indicating that virtual environments can support student learning when instruction is structured and access is consistent (Brodersen and Melluzzo, 2017).

Renaissance Learning percentile ranks showed a small advantage for students in the virtual environment, though the difference was not statistically significant. Still, the pattern suggests that virtual learning may offer certain benefits for students who prefer self-paced instruction, fewer classroom distractions, or flexible learning structures. These findings are consistent with previous studies showing that online environments can provide supportive conditions for at risk learners under the right circumstances (Powell et al., 2015).

Limitations

This study has several limitations that should be considered when interpreting the findings. The sample size was small because the district served a highly mobile population. Many students transferred in or out during the school year, which meant that complete reading data were not available for every student across all assessment periods. This level of mobility affected the consistency of the dataset and reduced the number of participants who met the criteria for inclusion.

Another limitation is that the study relied on existing STAR Reading assessment data provided by the district. Although STAR Reading is a widely used and reliable measure of reading performance (Renaissance Learning, 2020), it captures only one aspect of literacy achievement. Additional qualitative data may have provided deeper insight into students’ reading experiences.

Finally, the study examined data from one district, which may limit the generalizability of the findings. Demographic, instructional, and community factors vary widely across districts, and the outcomes may not fully reflect the experiences of African American students in other K–12 settings.

Implications for Practice

The findings of this study offer several important implications for educational practice. Schools should pay close attention to how instructional environments shape literacy outcomes for African American students in low-income communities. When virtual learning is offered without strong support, students who already face inequities may experience additional challenges. Educators should consider how access to technology, consistent communication, and structured reading support can strengthen virtual learning for students who need guidance.

Instructional leaders can use these findings to support professional development. Teachers may benefit from training that helps them deliver explicit reading instruction in both virtual and face to face settings. Research demonstrates that adolescent literacy improves when instruction includes direct strategy teaching and culturally responsive approaches (Deshler and Hock, 2007; Gay, 2020). Ensuring that these components remain present across learning environments can reduce reading gaps. Schools should also evaluate systems for monitoring reading progress. Continuous assessment and early intervention are essential for improving literacy outcomes, particularly for students who may need repetition or individualized support.

Future research should continue exploring how different instructional environments shape literacy outcomes for students who have historically experienced educational inequities. National data show enduring reading disparities for African American learners, which highlights the need for studies that examine long term trends (National Center for Education Statistics and Snyder, 2019; Singham, 2003). Mixed methods studies that integrate achievement data with interviews or observations may offer additional insight into students' experiences (Merriam and Tisdell, 2016; Zeni, 1998).

Studies with larger and more diverse samples would broaden understanding of how instructional delivery affects African American students in various contexts. Future research could also examine which instructional components in virtual settings most strongly influence reading growth, such as feedback, structured routines, or family engagement (Hsieh and Dwyer, 2009; Powell et al., 2015; Watson and Gemin, 2008).

Conclusion

This study examined whether African American low socioeconomic status ninth grade students demonstrated differences in reading achievement based on their instructional environment. The findings showed that virtual and face to face learners achieved similar outcomes. Although virtual learning offers flexibility, it may not always provide the structured literacy support that struggling readers need. This study highlights the ongoing importance of intentional instructional design, progress monitoring, and equitable access to resources across learning environments. Continued inquiry into the relationship between learning settings and reading development will help districts design practices that promote equity and academic success for all students.

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Play: Working Toward a Better Understanding and Approach in Teacher Education

by
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Abstract

This paper explores the challenges and opportunities in preparing preservice teachers (PSTs) to understand and implement play-based learning in early childhood education. Drawing from theory, neuroscience, and recent studies, it highlights the disconnect between the widely acknowledged value of play and its limited application in teacher education programs. Many PSTs enter programs with narrow or misguided definitions of play, shaped by their own structured childhood experiences and standards-based schooling. The paper argues for a more deliberate approach in teacher preparation, including initial perception assessments, personal reflection, experiential learning through play, and neuroscience-informed coursework. These strategies can help future educators recognize play as a cognitively demanding, developmentally critical tool rather than a non-essential classroom activity. Ultimately, redefining and embedding play within teacher education programs equips PSTs to foster holistic child development and advocate for play-based pedagogies in modern classrooms.

"How will children play in your classroom?" This is a question I ask every semester in my Introduction to Teaching course. The few middle level and secondary education majors always answer with *Kahoot* or a *Jeopardy* style trivia game. Since most of my preservice teachers are early childhood education majors, I press them further, "Games are good, but what will you do to encourage students to *play* in your future classroom?" Invariably, preservice teachers (PSTs) will answer with examples of learning centers in which students could rotate among stations with computer learning games, a kitchen, and dress up clothes. This exchange underscores, for me, that preservice teachers have a fundamental misunderstanding of what it means for children to play. It is therefore incumbent on teacher educators to prepare preservice teachers who understand the benefits and uses of a play-based curriculum.

Definition of Play

For play to be considered as play, the activity should be self-chosen, self-driven, enjoyable, intrinsically motivated and meaningful to children (NAEYC, 2020; Jones & Reynolds, 2011). Play is best viewed as a continuum, with guided play on one end and free play on the other (Miller & Almon, 2009). Researchers broadly identify three types of play: child-initiated play, adult-guided play and curriculum-driven play (Wood, 2014). In child-initiated play, children are intrinsically motivated, exploring and directing their own activities which encourages them to be creative and independent problem solvers. Examples of child-initiated play include playing with blocks, toy cars, action figures, dolls, play kitchens, puppets, pretend play, outdoor play, arts/crafts. In adult-guided play, teachers take the role of facilitators to support and guide a child's exploration. They set up a stimulating environment by offering prompts and materials to enrich the experience while still allowing the child to lead. Curriculum-driven play is mainly educational. Teachers plan play activities focusing on a particular concept and learning objectives and therefore, control the structure of the activity.

In the US, both child-initiated play and adult-guided play are mainly observed in childcare and preschools classrooms when children play with toys and materials (e.g., blocks, cars), each other (e.g., pretend play, socio-dramatic play) and table activities (e.g., puzzles, drawing) set up by adults. Curriculum-driven play can be seen in elementary/primary school classrooms when teachers use play activities to achieve their educational goals.

The Importance of Play

Play is an essential activity in early childhood, serving as a cornerstone for cognitive, emotional, social, and physical development. Play stimulates brain development and enhances cognitive functions (Weisberg, Hirsh-Pasek, and Golinkoff, b2013). Activities like puzzles, building blocks, and role-playing enhance problem-solving abilities, memory, and critical thinking (Yogman et al., 2018; Lillard et al., 2013). Through play, children engage in problem-solving, the development of language, and numeracy skills (Weisberg, Hirsh-Pasek, and Golinkoff, 2013). Play promotes creativity and innovation, providing children with opportunities to explore and experiment in a safe environment (Russ and Wallace 2013; Whitebread et al., 2012). Through play, children learn how to express their emotions, understand their feelings, and develop self-regulation. It also helps them build resilience and cope with stress (Hirsh-Pasek et al., 2009). Finally, research indicates that children who participate in play-based learning environments perform just as well, if not better, on standardized academic assessments compared to their peers in traditional, teacher-directed classrooms. This suggests that play-based learning does not hinder academic progress and may in fact support it (Marcon, 2002; Bodrova and Leong 2003).

The importance of play is being debated outside of the educational research setting as well. Two recent best-selling authors have waded into the discussion. In *The Anxious Generation: How the Great Rewiring of Childhood is Causing an Epidemic of Mental Illness*, author Jonathan Haidt (2024) argues that individuals born after 1996 have experienced a detrimental loss of play in their childhoods. Childhood play has been replaced by smartphones and what he calls “safetyism,” (89) which essentially overprotects children and robs them of their ability to play freely. According to Haidt, children need “Unsupervised outdoor play” (p. 68) because it teaches them “how to handle risks and challenges of many kinds” (p. 68). Likewise, in *Bad Therapy: Why the Kids Aren’t Growing Up* (2024), Abigail Shrier contends that the notion of play is being diminished in favor of more structured activities organized by parents. She argues that structured play prevents a child from being able to “blow off steam or test her limits or negotiate relationships with peers” (p. 54). It is only a matter of time before parents and caregivers begin to join this discussion, making it even more imperative for teacher education programs to have a plan for addressing this issue.

Most, if not all, teacher education programs require students to take a psychology course in which they learn about the cognitive and social development of the students with whom they will be working. The work of Jean Piaget and Lev Vygotsky are covered in these courses because their work on the development of children and their interactions with play are cornerstones of the field. Regarding children engaging in play, each touted specific theories that help preservice teachers understand the value of children playing together, playing with objects, and engaging in pretend play. While learning about Piaget’s stages of cognitive development (sensorimotor, preoperational, concrete operational, formal operational), students also learn that play helps children to create meaning and understanding of the world around them (Taylor & Boyer, 2019). When children play with the toys and objects in their environment, they can engage in repetitive activities that they will learn to master as well as use the objects in creative, novel ways (Wynberg et al., 2021). Vygotsky's stance on pretend play helps PSTs to understand the importance of play in developing social competence and socio-cultural norms (Smits van-der Nat et al., 2024).

Inservice and Preservice Teachers' Perceptions of Play

According to a study by Bubikova-Moran et al. (2019), inservice teachers express a lack of understanding of play theory and the benefits of play. Most believe play primarily benefits children's social skills and is viewed as lacking purpose and academic content. As such, this lack of understanding along with "juggling parental expectations leaves little room for play and may also affect teachers' own dispositions and attitudes" (p. 789). In a study of role-play in early childhood classrooms, Tympa, Karavida, and Charissi (2021) asserted that teachers differ in how they perceive their role during classroom play. The preservice and inservice teacher participants in their study believed their involvement during role-play activities influenced students' learning experiences, however, they believed the goals of play were mainly for social emotional learning, as opposed to academic learning.

A study by Author 1 (2019) followed four cohorts of preservice teachers in a mid-size mid-western university to gauge their perceptions of play at differing stages of their teacher education program. Preservice teachers at the beginning regarded play as a physical and social activity more so than a cognitive one. Those further along in the program regarded play more narrowly with rigid definitions of what constitutes play versus learning. What changed for these students during their 4-year program to influence this change in attitude? The most likely answer is their time spent in the field where they witnessed a diminished use of play and an increased focus on academic skills (Author 1 & Raisor, 2020). The play they did witness was learning through play-based activities, not learning through play itself. A key finding from this study is that PSTs each have their own definition of play that is influenced by personal experiences during childhood. As a result, it is not surprising that the importance of play for these participants was merely a fun activity, not rooted in actual learning. These preservice teachers grew up being more accustomed to structured play dates and organized sporting events, so much so that free play is not a familiar concept. In Author 1's study, the concepts of play and learning seemed not fully integrated in participants' minds; consequently, a fundamental link between play and learning may not have been established.

Play perceptions are difficult to change. Preservice teachers do come to realize that play significantly contributes to children's learning, but the preexisting knowledge creates barriers for establishing the link between play, learning, and development. What needs to be clarified, then, is the concept of learning. The deep-seated beliefs about play that originated in childhood have not been fully challenged, create barriers for understanding, and are difficult to change (Leaupepe, 2009).

Challenges for Teacher Educators

There are several challenges when teaching preservice teachers (PSTs) how to incorporate play into their classrooms. First, although play is an essential component of the early childhood curriculum, there is no clear, shared definition of play (Bubikova-Moan, Hjetland, & Wollschied, 2019; Author 1 & Raisor, 2020). At best, play is considered a range of activities on a continuum with varying degrees of teacher guidance (Altun, 2018; Bubikova-Moan et al., 2019; Author 1 & Raisor, 2020). Second, a focus on a standards-based curriculum undermines the role of play in the classroom. Current preservice teachers have grown up in schools that were intensely focused on standardized testing (Galbraith, 2022). Furthermore, once these PSTs begin field experiences in schools, they meet teachers who feel pressure from policy-makers, curriculum demands, time constraints, and parental expectations to focus on learning outcomes that do not involve play (Tympa, Karavida, & Charissi, 2021). Furthermore, teachers have a responsibility to supervise student actions which results in less free play time (Haidt, 2024). Third, the COVID-19 pandemic exacerbated notions of learning loss and gaps in achievement, especially for students with low income (González et al., 2022). During the lockdown and subsequent staggered school schedules, children worked in isolation with fewer hands-on materials thereby diminishing the opportunity for interactive and social play (Crawford et al., 2021).

Finally, the preservice teachers in our programs today grew up with smart phones – affording them easy access to all sorts of games and diversions. Haidt (2024), argues that the current generation of young people experienced a childhood in which parents were overly cautious coupled with the advent of the smartphone. This led to a decrease in the amount of childhood play and an increase in reliance on smartphones and an overindulgence of social media and online gaming. It stands to reason that those currently studying to become teachers or are novice teachers, lack a fundamental understanding of play and its benefits.

Because of these challenges, teacher educators need to have a clear understanding of preservice teachers' perceptions of play. Teacher educators must address misconceptions and instill the value of play-based learning in a novice teacher's teaching philosophy. Research (i.e. Jung & Jin, 2014; Jung, Zhang, & Zhang, 2016; Author 1 & Raisor, 2020) indicates that the perceptions preservice teachers have about play have a strong connection to the importance they will place on it in their future classrooms. Teacher education programs have a significant impact on PSTs' perceptions of how play should be used in the classroom. Therefore, teacher educators have a responsibility to prepare them with a clear understanding of the relationship between play and learning (Altun, 2018; Tympa et al., 2021; Author 1 & Raisor, 2020). Building the bridge between theory and practice is a first step in helping PSTs to understand the need to involve children in play activities, both free play and structured play. Given that perceptions of play differ based on cultural and community norms (Göncü & Gaskins, 2001), creating a shared understanding of play is also an important step for teacher education programs. Because there is not a shared definition of play in the research literature, each program has the unique opportunity to define it as they see fit.

Implications for Teacher Education and Professional Development

There is disparity between the theoretical emphasis on the importance of play in early childhood education and its practical implementation within teacher education programs (Galbraith, 2022). Despite a widespread recognition of play as a fundamental component for children's development, early childhood teacher education programs often fail to adequately integrate play-based learning into their curricula. This disconnect results in new educators feeling underprepared to effectively employ play-based strategies in their classrooms. It would behoove teacher educators to work within the confines of their programs to develop a comprehensive definition of play that could be used to support PSTs' philosophical development (Author 1 & Raisor, 2020). Preservice teachers need leave the college with understanding that "Playing with children is not simply an enjoyable way for teachers to spend time in the classroom; it is a cognitively challenging act that requires knowledge, reflection, and purpose" (Trawick-Smith & Dziurgot, p. 127, 2010).

Practical Recommendations and Strategies

Based on the identified challenges in teaching play within teacher education, we propose three practical recommendations: (1) initial assessment, (2) personal reflections, and (3) teaching through play and (4) play course based on neuroscience research. Each of these is described in detail below.

1. Initial Assessments. Assessing preservice teachers' (PSTs) initial perceptions of play is crucial for designing more targeted and effective instructional strategies. Just as biases shaped by personal experiences can influence how teachers treat students and content, PSTs' own backgrounds with play can affect their approach to incorporating it in the classroom. Understanding these perceptions provides a foundation for teaching them about the benefits of play (Altun, 2018; Samuelsson & Carlsson, 2008).

At the start of a course, an activity that encourages PSTs to reflect on and discuss their perceptions of play can help establish a baseline understanding. This discussion not only offers insights into their current beliefs about play but also provides teacher educators with valuable information to guide their teaching. Understanding how PSTs define play, and how these definitions shape their attitudes toward using play in the classroom, is key. This activity helps identify how PSTs view the role of play in learning and whether they see play as an integral part of child development or something separate from serious learning. Recognizing where PSTs stand on these issues allows teacher educators to tailor their approach and ensure that instruction meets the needs of the cohort, acknowledging that these perceptions may shift over time.

In an introductory or methods course, this discussion could look something like this:

- Written reflection: PSTs' reflect on: how important was play to your development as a child? What is the purpose of play in the classroom? Do you believe play is an essential part of learning? Why or why not?
- Class Discussion: teacher educators gauge initial perceptions of play through discussions of PSTs' preconceived notions of play, personal experiences, and their understanding of how these perceptions will influence their teaching.
- Follow-up: Perceptions are discussed and summarized to be used as a baseline understanding as PSTs learn more about the role of play in child development.
- Continuation: Teacher educators revisit this baseline throughout the course to illustrate PSTs' changes in understanding and to help them become more reflective in understanding the role of play in the classroom.

2. Personal Reflections. Including reflective assignments and discussions in teacher education programs is essential for helping preservice teachers critically assess and develop their understanding of play in early childhood education (Zeichner & Liston, 2013). Korthagen & Vasalos (2005) emphasize the importance of different levels of reflection, which can be facilitated through structured assignments, for the professional growth of teachers. Reflection enables preservice teachers to critically evaluate their teaching practices, including their approach to play, and adjust them to better support children's development.

To deepen preservice teachers' understanding, it is crucial to engage them in reflections that focus on their perceptions of play. As Altun (2018) points out, understanding these perceptions helps shape more effective teacher education programs. Adamson, Rouse, and Emmet (2021) further stress that reflecting on personal experiences with play helps preservice teachers reconnect with this universal aspect of childhood. By doing so, they can develop a deeper appreciation for its value and begin to integrate it meaningfully into their future classrooms. Consider these guidelines for reflective assignments and discussions:

- Personal experiences with play: PSTs reflect on their childhoods, the types of play they experienced, and how this affects their perceptions of play in schools.
- Evaluate the importance of play in child development: PSTs reflect on and discuss different types of play (free play versus structured play) and how play influences children's social, emotional, and cognitive development.
- Bridging theory and practice: require PSTs to link theoretical concepts of play to real classroom situations.
- Address misconceptions: help PSTs identify and challenge misconceptions or preconceived notions about play, such as seeing play as a break from the day's learning.
- Continuous reflection: engage PSTs in ongoing discussions about play throughout their teacher education program so they better understand the value of play-based learning.

Such ongoing discussion and reflection activities throughout training can help PSTs recognize play not only as a tool for social development but also as a means of supporting cognitive, emotional, and physical growth. In addition to developing a broader perception of play, there is value in emphasizing the learning outcomes in play experiences. This approach ensures that preservice teachers are better prepared to utilize play in ways that enhance child development in their future classrooms.

3. Teaching Through Play. Preservice teachers can gain a deeper understanding of play's benefits by experiencing it firsthand. As Adamson, Rouse, and Emmett (2021) note, "Experiential learning about play reconnects teachers with their own play experiences, bridging their beliefs with emerging understandings of play as pedagogy" (p. 365). Observing and engaging in play-based environments allows PSTs to connect theory with practice (Howard & McInnes, 2013; Wood 2014). Hands-on learning, such as outdoor play, is essential for integrating theoretical concepts into real-world teaching. Tympa, Karavida, and Charissi (2021) suggest incorporating theater training into early childhood programs to improve PSTs' engagement through role-play.

Recess is often synonymous with play, and research highlights its benefits for students' physical, behavioral, and academic outcomes. Hodges, Centeio, and Morgan (2022) found that recess positively impacts overall well-being, with no negative effects identified. Howie et al. (2023) also link physical activity to improved educational outcomes. Advocating for more recess, such as through the Let Grow Project, could help reintroduce play into students' daily routines (Haidt, 2024).

Thus, Author 1 and Raisor (2020) argue that teacher education should focus on teaching *through* play, not just about play. By experiencing play firsthand, PSTs can challenge misconceptions and witness its impact, aligning with the brain's natural learning processes and fostering engagement and motivation (Hirsh-Pasek et al., 2009). In addition, PSTs can observe developmentally appropriate play in the context of a real classroom that is culturally relevant, linguistically inclusive, and supports the whole child (NAEYC, 2025).

4. Play Course Based on Neuroscience Research. Author 1 (2019) suggests that preservice teachers (PSTs) can gain a deeper understanding of learning and the role of play through targeted coursework. A course in early childhood education should incorporate neuroscience principles, helping PSTs understand the brain-body connection and how play actively shapes cognitive, social-emotional, and motor development. Neuroscience research findings suggest that play enhances neural pathways, promoting cognitive flexibility, problem-solving, and self-regulation (Gopnik, 2020). Moreover, results of studies that used neuroimaging point out the value of unstructured play as it stimulates prefrontal cortex, which is crucial for executive function and long-term memory (Center on the Developing Child 2016).

Through intentional instruction based on neuroscience of play, teacher educators can equip PSTs with the knowledge and confidence to advocate for play in early childhood curricula. A clear understanding of how young children build knowledge through play will empower future educators to incorporate play-based pedagogy effectively, even in test-driven environments. Additionally, professional development workshops can help both novice and experienced teachers advocate for the inclusion of play and extended recess, ensuring that early learning environments support optimal brain development.

Conclusion

Research (i.e. Bubikova-Moran et al., 2019; Tympa, Karavida, and Charissi, 2021) shows that preservice teachers vary on their perceptions of play. Like most perceptions, these beliefs are due to personal experiences throughout childhood. The field of education lacks a comprehensive definition of play. Coupled together, these two issues make it difficult for PSTs to understand how play could be incorporated into their future classrooms. Teacher educators have a responsibility to make sure the PSTs in their care develop a clear philosophy of play and its importance in the classroom. Research (i.e. Haidt, 2024; Russ & Wallace, 2013) also shows that play is of tantamount importance to the social and academic well-being of students. In addition, teacher educators are faced with many challenges when working with the current generation of PSTs. A lifetime of standards-based schooling, a structured childhood experience, and the influence of smartphone technology have made incorporating play into the curriculum even more daunting. Explicitly defining the meaning of play in a teacher education program, as well as instituting neuroscience research-based play course as well as specific activities surrounding play, may help PSTs better understand the importance of play in their future classrooms. Such activities include examining their perceptions of play, reflecting on their experiences with play, gaining knowledge on how brain works and learning through play in the classroom. Finally, PSTs should advocate for recess to be examined and championed.

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An Investigation of Elementary Teachers' Implementation
of Culturally Responsive Teaching
by
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Abstract

The study examines elementary teachers in Central Illinois implementing culturally responsive teaching (CRT) practices in the classrooms. A cross-sectional survey method was used to examine a total of 469 teachers of kindergarten through fifth grade implementing CRT practices the most and least, and to find out if there was a relationship between implementation and student demographics, and teacher characteristics. The results of the study revealed that teachers are doing CRT practices are more general in nature and less specific to meeting culturally linguistically diverse students' needs or addressing diversity. There were significant correlations between the demographic and number of English Language learners and CRT implementation, however, there was no significant correlation between teacher demographics and implementation of CRT practices.

Over the last few decades, culturally and linguistically diverse populations have been growing significantly in the United States (U.S.) [U.S. Census Bureau, 2015]. According to the National Center for Education Statistics (NCES), from 2003 to 2013, the number of Hispanic students enrolled in public schools increased from 19% to 25%, and 4% to 5% for Asian/Pacific Islander students, while the percentages of African American and White students fell (NCES, 2016).

In Illinois, the achievement gap between White and African Americans in 2007 was one of the highest in the U.S. in both mathematics and reading; in math, the gap was 32 points for fourth grade and 38 for eighth grade. In reading, the achievement gap was 29 points for fourth grade and 27 for eighth grade (NCES, 2016). The achievement gap between Hispanics and Whites has remained relatively constant from 1992 to 2009, being in the range of 28-25point difference in scores in grade four, and 27 to 24 points in grade eight. There has not been a significant increase or decrease in the past two decades showing a lack of improvement.

Federal mandates require all U.S. school administrators and educators responsible for the educational achievement of all students, including English language learners (ELLs) and minorities, by providing high quality education to each student (Every Student Succeeds Act of 1965, 2015). Currently, most culturally linguistic diversity (CLD) students in Illinois spend the majority of their instructional day in the general education classroom taught by teachers who may have had or have limited opportunities to learn how to address CLD students' language, learning, and social-emotional needs (Gay, 2018; Plata, 2011). As a result, many teachers are unprepared or incompetent in how to address and teach CLD students (Ebersole et al., 2015).

Teachers not only be unaware of cultural biases, but they also may not be culturally competent. Teachers that work to be unbiased and remove stereotypes about students are likely to create an inclusive and appropriate classroom environment for students that will help them achieve academically and grow socially and emotionally. There is a wide range of ways that teachers can be ill-prepared to effectively teach CLD students. Teachers may not be culturally competent in the areas of discipline, interactions, perceptions about school and teachers, gender roles, language, and expectations as they relate to diverse students and their families (Gay, 2018). Teachers from the dominant, White culture may also not recognize or acknowledge their "whiteness" as an inherent part of their everyday behaviors and interactions (Gay, 2018) and are not prepared to teach CLD students or multicultural education, which may also be contributing to the lack of achievement of minority students compared to White students.

Many teachers may be under the impression that they are being culturally responsive simply by incorporating multicultural literature or a few lessons on a culture during a certain labeled month of the year, which is sometimes referred to as the "tourist approach" of multiculturalism (Banks, 1999). This perception of diversity and its place in the classroom leads to a superficial expression of the role culture plays in students' lives and society.

Thus, administrators need teachers that pay special attention to recognizing and valuing these cultural differences to provide the most appropriate and meaningful education for each student. The standardized tests scores indicate an obvious achievement gap among Whites and CLD students (Ebersole et al., 2015) may not only impact the school's reputation, but also the opportunity for funding that is given by the government.

Culturally Responsive Teaching

Culturally responsive teaching (CRT) is a theoretical framework that can be implemented to help improve the academic achievement and emotional well-being of all students (Ladson-Billings, 2021). It is acknowledged and values students' cultures, language, and experiences by creating a learning environment where all students can succeed, regardless of their backgrounds. Educators need to adapt their teaching methods and curriculum to reflect the cultural identities of their students, fostering a sense of belonging and engagement by creating classroom environment where diverse students feel seen, respected, and empowered to learn using their cultural capital as an asset (Gay, 2018).

CRT encourages teachers to challenge the stereotypes attached to students and recognize the unique cultural assets that contribute to the social constructs of a classroom. It is grounded in the idea that all students can achieve, given that the teacher provides the most appropriate learning environment and instruction based on the unique assets the students bring to the classroom. Teachers who are culturally competent also acknowledge their own cultural identity. If even teachers are White, they need to perceive themselves as being part of a culture that has certain attributes and norms. When implementing CRT in the classrooms, these are the factors need to be considered – student background and experiences, teacher dispositions, curriculum contents, instructional pedagogy, and professional development.

According to Gay (2018) there are six elements in CRT that addressing diversity teachers to implement in the schools.

- A strong knowledge-based about cultural diversity and understanding cultural context
- Culturally relevant curriculum
- Affirming students' identities, appreciation for different communication styles, and high expectations for all students
- Critical consciousness
- Flexible teaching strategies and the use of multicultural instructional examples
- Building relationship with families

Teachers need to successfully put CRT theory into practice because it involves understanding of learning, language, communication, culture, society, content, and history. Teachers must also know and learn about their individual students' experiences, culture, and interests plays a role in the dispositions that teachers develop (Toppel, 2015). Cultural relevant curriculum and linguistic competence is one component at the foundation of CRT. Culture is a broad concept affected by multiple contextual factors: time, socioeconomic status, history, location, language, religion, education, age, and gender (Gay, 2018). It is essential that teachers have a well-developed understanding of culture, as well as knowledge about cultural characteristics of diverse ethnic groups (Gay, 2018). This statement is not to imply that every student with a particular racial or ethnic background will display those racial or ethnic traits or to encourage a teacher to stereotype or label students. Teachers who are culturally competent also acknowledge their own cultural identity.

Each student brings with them a sum of perspectives, abilities, and live experiences that affect how they learn, communicate, and behave. If a teacher wants to appropriately align lessons and objectives to be responsive to students' needs and motivate them to learn, then they must truly know their students (Toppel, 2015). Teachers that work to build a repertoire of knowledge of various cultures and their individual students' interests and lives, begin to develop a positive disposition and sociocultural awareness.

Teachers that hold high expectations for all students have "uncompromising faith in their students and relentless efforts in helping them meet high academic standards" (Gay, 2018, p. 76). High expectations need to be clear and communicated to all students, with more depth than a general statement of confidence. Minority ethnic and racial students, females, and low ability students are more likely to experience decreased achievement outcome and opportunity because teachers do not always give fair attention and persistent effort to these students (Gay, 2018). Teacher disposition is at the heart of CRT (Ebersole et al, 2015). CRT cannot truly be implemented unless teachers hold an affirming disposition for all students and believe in the ideologies that support CRT and multicultural education.

A teacher that recognizes the need to implement CRT after learning about his or her students most likely has critical consciousness. Critical consciousness included the aspect of sociocultural awareness, is the ability for one to analyze and reflect on one's own beliefs and understandings about how culture, ethnicity, experiences, attitudes, and language influence education (Plata, 2011; Saifer et al., 2014). In Central Illinois majority of the teachers are White, and many of the students are as well. It is imperative that White teachers recognize the notion of "whiteness" and how possible prejudices and biases can be present in the community and school (Tran, 2015). Educators' individual biases that are unchallenged may transcend into the school, classroom, and instruction, which lead to misunderstandings, stereotypes, and false accusations of CLD students that can negatively affect their social-emotional and academic well-being (Plata, 2011).

The critical consciousness, which also involves the assertion of a hierarchical society that is preserved through "systematic discrimination" (Plata, 2011). Developing critical consciousness requires analyzing how and why the dominant culture in society "…directly affects public school goals, policies, and practices in ways that can undermine the academic achievement of students of color" (Vavrus, 2008, p. 52).

The ways that teachers perceive differences will impact the school and classroom environment, and student learning, therefore, it essential that differences in culture and learning are acknowledged and viewed in a positive manner. Viewing differences positively may be referred to as an "assets rather than deficits" model (Vavrus, 2008 p.53). The assets that students may bring with them can be in various forms of capital: aspirational, linguistic, familial, social, or resilience. Teachers that recognize students' differences as beneficial capital and use it in their teaching are more likely to have a positive impact on diverse students' academic achievement (Gay, 2013).

CRT is not teaching 'about' content but 'through' content (Ebersole et el., 2015). Culturally responsive teachers analyze the formal, informal, and symbolic curriculum in schools for misrepresentation or lack of representation of minority racial and ethnic groups, women, and people with disabilities. It is suggested that teachers incorporate topics and perspectives based on a wide range of ethnic individuals and groups including controversial issues (Gay, 2018).

Teachers' pedagogy, instructional techniques, and assessment used in the classroom indicate whether the teacher believes in and supports the theory and practices of CRT. The types of assessments that are used to evaluate student progress should be formative, varied, and authentic. Culturally responsive teachers present opportunities for students to display their learning in ways that support students' culture and interaction styles by providing opportunity for specific and helpful feedback for students. Feedback can also be informal and immediate, given throughout lessons and discussions (Aceves & Orosco, 2014). CRT encouraged teachers to use the constructivist approach by providing scaffolding through various techniques, including relevant examples and modeling (Saifer et al., 2014). Teaching and learning have a purpose that revolves around students' experience and knowledge that they possess and does not involve a rigid framework (Vavrus, 2008).

Teachers ought to capitalize on the valuable knowledge of parents and family members when possible to help their students succeed by including them in learning activities (Saifer et al., 2014). By creating an inclusive environment, the interactions can take place through informal and formal activities, such as parent volunteers to read dual language and multicultural books, speak about cultural traditions, or simply help with daily activities in the classroom.

Professional Development

CRT has been challenged to be considered 'just good teaching' (Ladson-Billings, 2021, p. 159), but the lack of implementation and knowledge of how to be culturally responsive by teachers proves otherwise. Studies indicate that teachers are not adequately prepared within their dispositions to teach CLD students or multicultural education, nor have the knowledge- based to do so (Ebersole et al., 2015; Tran, 2015). This could indicate a need to address the CRT in teacher education preparation programs including professional development for teachers.

A great deal of administrations in Illinois' schools use the Danielson Framework to evaluate teachers which contains various components related to culturally responsive teaching, such as “Demonstrating Knowledge of Students,” “Creating an Environment of Respect and Rapport,” “Communicating with Students,” “Demonstrating Flexibility and Responsiveness.” The framework also has a domain dedicated to the professional responsibilities of the educator, which involves reflection, communication with families, and participating in ongoing professional growth and development (Adams, et al., & Association for Supervision and Curriculum Development, 2013). Thus, the use of CRT could greatly benefit teachers in meeting the evaluation standards administrators use to judge them.

The Study

The study utilized a quantitative approach using a cross-sectional survey to examine if Central Illinois elementary K-5 teachers implement culturally responsive teaching methods. The overarching research question was: Are elementary K-5 teachers implementing CRT? and three specific research questions guided the study:

- What aspects of culturally responsive teaching are teachers implementing the most and least?
- Is there correlation between student demographics and the implementation of culturally responsive teaching?
- Is there correlation between teacher characteristics and the implementation of culturally responsive teaching?

Four hundred sixty-nine public school teachers teaching kindergarten through fifth grade from 39 counties in Central Illinois were participated in the study. The years of teaching experience of the sample ranged from 0 to 26. The largest portion of the sample (22%) comprised teachers with 6-10 years of experience. The least represented teaching experience group was those with 26 or more years of experience, being approximately 16% of the sample. Over half of the sample had Master’s degrees, with about 26% having only a Bachelor’s degree. Only 7% of the sample indicated that they had an ESL endorsement or teaching certificate.

A self-developed survey questionnaire was developed based on four previously established instruments: The Multicultural Teaching Competency Scale (MTCS) (Spanierman, et al., 2011), Culturally Responsive Teaching Self-Efficacy (CRTSE), Culturally Responsive Teaching Outcome Expectancy (CRTOE) (Siwatu, 2007), and the Culturally Responsive Teacher Preparedness Scale (Hsiao, 2015).

The first instrument, The Multicultural Teaching Competency Scale (MTCS) (Spanierman, et al., 2011) [α =. 611], was developed to create a more comprehensive multicultural competence scale. The second and third instruments, Culturally Responsive Teaching Self-Efficacy (CRTSE) [α= .812], and the Culturally Responsive Teaching Outcome Expectancy (CRTOE) (Siwatu, 2007) [α =.739], were created to evaluate if preservice teachers have the beliefs and self-efficacy to be culturally responsive teachers. The last instrument, The Culturally Responsive Teacher Preparedness Scale (Hsiao, 2015) [α =.799], was created to determine preservice teachers’ culturally responsive teaching competencies that could be used in teacher preparation programs. Hsiao’s study focused on factor analysis of the instrument. The survey questions were to determine if they aligned with the foundational literature from Gay (2018). The survey instrument for this study had a Cronbach alpha of .785 and was imported to the Qualtrics for the participants to answer the questions.

The instrument had a total of 35 questions;18 items were about culturally responsive teaching practices, and 17 were related to teacher and student demographics. For all of the questions regarding CRT teacher practices, a Likert scale of 1-5 was utilized; Never—I have not done this at any time nor attempted to do so; Rarely – I’ve attempted to do this, but only once or twice; Sometimes—I’ve done this on occasion, or partially; Often – I do/have done this but not as consistently or fully as I could; and Always—I do/have done this fully and/or consistently. Data was analyzed using central tendency and Pearson correlation using SPSS to find out which CRT practices teachers are implementing the most and least and to determine if there was a correlation between the independent variables of teacher and student demographics and the dependent variables of teacher CRT practices.

Results and Findings

Research Question One: What Aspects of Culturally Responsive Teaching are Teachers Implementing the Most and Least? The overarching research question sought to answer if elementary teachers are implementing CRT overall. Data shows that teachers communicate high academic expectations (*M* = 4.66, *SD* = .645) and provide a fair amount of attention with the highest mean of 4.61 (*SD* = .518) for students. Another aspect of teaching that reflect teachers' practice CRT was the teachers reflected some of the CRT aspects on their teaching (*M* =4.50, *SD* = .649) and use a variety of assessments tools to evaluate student from diverse academic backgrounds (*M* = 4.10, *SD* = .842) that are appropriate to CRT. Table 1 illustrates mean and standard deviation of aspects of CRT that teachers implemented in the classrooms.

Table 1. Mean & Std Dev of Teachers' Culturally Responsive Teaching Pract (n=469)

CRT Items	Mean	Std Dev
1. Collect data on students' interest & learning	3.71	.867
2. Collect data on parents' culture & preferences	2.98	1.429
3. Analyze curriculum & instructional materials for misrepresentation/lack of representation	3.11	1.165
4. Use supplemental materials to counteraction misrepresentation/lack of representation	3.22	1.181
5. Explicitly facilitate conversations on unpopular or taboo topics	2.75	1.120
6. Evaluate the appropriateness of assessment tools	3.32	1.207
7. Use a variety of assessment tools other than tests	4.10	.842
8. Reflect on my teaching weekly	4.50	.649
9. Model and teach social justice and equal opportunity	3.59	.973
10. Help students identify how they are different and alike	3.80	.894
11. Evaluate if cultural practices and beliefs are different or alike than students	3.52	1.003
12. Provide a fair amount of attention	4.61	.518
13. Greet ELLs in native language	2.39	1.469
14. Identify school expectations & culture different or alike than students	2.78	1.172
15. Set and communicate high academic expectations	4.66	.645
16. Develop standard-aligned rigorous learning activities	3.96	.862

The least aspects of CRT teachers implemented in the classrooms are greet ELLS in native language (*M* =2.39, *SD* = 1.469), explicitly facilitate conversations on unpopular or taboo topics (*M* =2.75, *SD* = 1.120), and identify and record the ways in which the school culture and expectations are different than my students' culture and at-home expectations (*M* = 2.78, *SD* = 1.172).

To examine if there was a relationship between the highest and lowest scores identified by research sub-question one; the correlation between practices, three highest mean scores and lowest scores from the survey were analyzed. The results showed there were no correlations between the items, except for item on "Identify how school expectations and culture are different or alike than students," with "Identify school expectations and culture" and "Reflect on my teaching weekly" (r =.20, p <.01), "Provide a fair amount of attention," (r =.13, p < .01) "Set and communicate high expectations" (r =.18, p < .01). Thus, all the high scoring items had a positive correlation with only one of the low scoring items, "Identify school expectations and culture." This indicates that there was a weak relationship between the most and least CRT items. See Table 2.

Research Question Two: Is there Correlation Between Student Demographics and the Implementation of Culturally Responsive Teaching? The results indicated that there were some significant correlations between student demographics and teacher implementation of CRT practices. See Table 2. Teacher evaluation and assessment has the highest correlation with the number of ELLs (r = .24, p <. 01). The other two highest items were teachers analyzed materials for misinterpretations with ELLs, and teacher used supplemental materials and with the number of ELL with ELLs (r = .23, p <.01). The lowest correlations were teachers set and communicate high expectations and goal with ELLs (r = -.03, p <.05), provide fair attention (r = 0.00, p <.05), model and teach social justice (r = 0.10, p < 0.05), and evaluate own culture how like and different (r= 0.20, p <.05) with the number of ELLs. See Table 2.

Table 2. Pearson Correlation between Teachers' Culturally Responsive Teaching Practices and Student Demographics (n=469)

CRT Items	Student Demographics 1	2	3	4	5	6	7	8	9	10	11
Collect student interests	.05	.00	.00	.09*	.09	.03	.09*	.12**	.06	.05	.01
Collect info about parents' culture	.03	.03	-02	.08	.06	-.03	.77	.04	.00	.06	.02
Analyze materials misrepresentations	.17**	-.00	-03	.15**	.08	.11*	.10*	.15	-.11*	.23**	.13**
Use supplemental materials	.15**	.00	-04	.09*	.08	.11*	.08	.13**	-.08	.23**	.08
Explicitly facilitate unpopular topics	.15**	.05	.03	.08	.05	.08	.06	.17**	.17**	.17**	-.03
Evaluate assessments	.14**	-.00	-05	.13**	.11*	.10*	.06	.09	-.08	.24**	.12**
Use a variety of assessments	.04	.05	.03	.05	.00	.06	.08	.10*	-.00	.04	.04
Reflect on teaching	-.00	.10*	.07	.05	.00	.04	-.02	.11*	-.06	.03	.13**
Model and teach Social justice	.06	.07	.09	.06	.03	.05	.08	.13**	-.03	.10*	.04
Help students alike and different	.04	.04	.00	.01	.10*	.10*	-.01	.06	-.06	.14**	.00
Evaluate own culture alike & diff	.14**	.06	-.16	.10*	.09	.14**	.02	.15**	-.04	.20**	.05
Provide fair attention	-.01	.05	-00	-.09	-.03	.03	-.09	.03	-.15**	.00	-.00
Greet ELLs in native language	.19**	-.10	-03	.02	-.06	.06	.03	-.02	-.12*	.24**	.07
Identify school culture & expect same or different than students	.11*	-.01	-04	.10*	.02	.10*	.06	.03	-.07	.12**	.02
Set & comm. High expectations	-.03	.03	-00	.09	.01	.03	.05	.10*	-.00	-.03	.06
Develop standard Aligned activities	.07	.04	.05	.05	.02	.08	-.00	.07	-.05	.08	.03

Note: 1= number of Hispanic or Latino students, 2= number of non-Hispanic or Latino students, 3=number of White students, 4= number of Black or African American students, 5= number of American Indian or Alaskan Native students, 6= number of Asian students, 7= number of Native Hawaiian or Pacific Islander students, 8= number of students two or more races, 9=

grade level of students, 10= number of English Language Learners, 11= number of students new to the school or district
**p < .01, two tailed; *p < .05, two tailed

The number of ELLs teachers have in their class seems to affect whether they greet the ELLs in their native language. Though "Greet ELLs in their native language" is among one of the lowest scoring items on the survey (*M* = 2.4, *SD* =1.5), this is most likely because majority of the sample (66%) did not have ELLs in their classrooms as illustrated in Table 2. The correlation results show that there is a significant correlation between teachers that have ELLs, and if they greet ELLs in their native language. Thus, teachers that do in fact have a number above zero of ELLs in their class may be likely to greet them in their native language (see Table 3 and Table 4), since there is a significant correlation of .24 (p<.01). Of those that have 16 or more ELLs, 100% of them sometimes or more consistently greet ELLs in their native language. Teachers that have 1-5 ELLs, less than half, or 41%, sometimes or more consistently greet ELLs in their native language

Table 3. Teachers' Ratings on Greeting ELLs in Native Language based on Number of ELL Students ELLs (n= 158)

Rating on Likert Scale	Number of ELL Students			
	1-5	6-10	11-15	16+
Never	33	3	1	0
Rarely	36	3	2	0
Sometimes	25	11	0	3
Often	13	5	0	3
Always	11	2	3	6
Total	118	24	6	10

The race and ethnicity of students was based on numerical data input based on the percentage (see Table 4). As a result, only the mean and standard deviation are available to examine approximately how many students that teacher had based on race and ethnicity (see Table 5).

Table 4. Percentage of Number of ELL

Number of ELL	Percent
0	66.31
1-5	25.16
6-10	5.12
11-15	1.28
16+	2.13
Total	100

Table 5. Mean and Std Dev of Number of Students by Ethnicity

Ethnicity	Mean	Std Dev
White	15.7	7.9
Black or African American	2.73	4.01
Hispanic or Latino	1.37	2.86
American Indian or Alaska Native	0.04	0.22
Asian	0.50	1.55
Native Hawaiian or Pacific Islander	0.05	0.42
Two or more races	1.41	2.11

There were also correlations between the number of Hispanic students a teacher has and the implementation of CRT practices. The strongest correlations were "Greet ELLs in native language" (r = .19, p <.01), "Analyze materials for lack of or misrepresentations of CLD students in materials" (r = .17, p <.01), and "Use supplemental materials to counteract the lack of or misrepresentations of CLD students in materials" (r = .15, p <.01).

The results from these correlations show that the number of Hispanic students a teacher has may affect whether a teacher greets ELLs in their native language, analyzes materials for lack of or misrepresentations of CLD students, supplements the lack of or misrepresentations of CLD students, and explicitly facilitates conversations about unpopular topics with students. There was a correlation between the student demographic of number of students two or more races and CRT practices. The strongest correlation was "Explicitly facilitate conversations about taboo or unpopular topics" *(r = .17, p <.01)*. Table 5 illustrates approximately how many students that teachers had that were ELL. The highest correlations of CRT with African American and Asian students were "Analyze materials for misrepresentations", r =.15 *(p <.01)* and r = .11 (p <.01) respectively. For Asian students, "Evaluate own culture how alike and different was also have high correlation of CRT (r = .14, p <.01). See Table 1. There were weak correlations between student demographics of non-Hispanic, White, Native American, or Pacific Islander and CRT practice. There was also no correlation between CRT practices and the grade level of the classroom, except for one CRT item, "Explicitly facilitate conversations about unpopular or taboo topics, of *(r =.17, p < .01)*. Thus, the only student demographics that seem to impact more of teachers' implementation of CRT practices are if students are Hispanic, and students who have two or more races.

Research Question Three: Is There Correlation Between Teacher Characteristics and the Implementation of Culturally Responsive Teaching? The results show there was a weak correlation between teacher characteristics and implementation of CRT (see Table 6). There were two characteristics that had significant correlations on nearly every CRT practice; characteristic 10, "Guide or instruct practicum students or student teachers on CRT" (r = .48, p <.01), and characteristic 11, "Check over or evaluate practicum student lessons on CRT" (r =.50, p <.01). Teacher race had two significant correlations that were both at r = .13 *(p <.01)* with the CRT practice "Use supplemental materials to counteract lack of or misrepresentation of CLD students," and "Identify how the school culture is different or alike to students' at-home culture" (see Table 6).

Table 6. Pearson Correlation between Teachers' Culturally Responsive Teaching Practices and Teacher Characteristics (n=469)

CRT Item	Teacher Characteristics												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Collect students' interest	-.17	.05	-.03	-.18**	.02	-.10*	-.21**	-.16**	-.02	.38**	.33**	.12*	.04
Collect info about parents' culture	-.02	.68	-.16**	-.12*	-.10*	-.00	-.07	-.08	.00	.21**	.23**	.14*	.02
Analyze materials misrepresentations	-.06	.11*	-.03	-.25*	01	-.20**	- .19**	-.24**	-.06	.48**	.50**	.13*	.19*
Use supplemental materials	-.01	.13**	-.06	-.22**	-.03	-.19**	-.20**	-.19**	-.03	.46**	.49**	.11	.24**
Explicitly facilitate unpopular topics	-.04	.13**	-.15**	-.13**	-.02	-.08	-.16**	-.15**	-.01	.29**	.27**	.10	.19*
Evaluate assessm	-.07	.06	-.05	-.20**	-.01	-.21**	-.25**	-.22**	.01	.50**	.52**	-.12*	.02
Use a variety of assessments	.04	.08	-.06	-.11*	-.02	-.10*	-.10*	-.05	-.04	.32**	.30**	12*	.09
Reflect on teaching	-.00	.05	.-01	-.04	-.03	-.03	-.12*	-.15**	-.02	.31**	.25**	-.12*	.01
Model and teach social justice	-.05	.08	.00	-.08	-.03	.02	-.12**	-.08	-.04	.17**	.21**	-.09	.00
Help students alike & different	.02	.07	.02	-.10*	-.02	-.07	-.13**	-.10*	-.08	.30**	.30**	.15*	-.04
Evaluate own cult alike & different	-.09*	.08	-.03	-.22**	.07	-.10*	-.20**	-.20**	-.06	.40**	.40**	-.17*	.01
Provide fair atten	.06	.02	.04	.02	.02	-.01	-.02	-.03	-.04	.24**	.23**	-.01	-.07
Greet ELLs in native language	-.09	-.01	-.04	-.10*	.03	-.14**	-.16**	-.17**	-.07	-.15**	.12*	.09	-.07
Identify school Cult & expect	-.02	.13**	-.10	-.14**	.03	-.09*	-.13**	-.13**	-.06	.41**	.40**	.17**	.05

Set & comm. high expect	.03	.02	.-01	-.15**	.04	-.00	-.11*	-.16**	-.03	.29**	.26**	-.15**	.02
Develop align activities	.02	.07	.01	-.06	.00	-.05	-.13**	-.16**	-.05	.34**	.30**	-.04	.05

Note: 1= teacher ethnicity, 2= teacher race, 3= total number of years teaching, 4= location of current teaching position, 5= level of highest education earned, 6= certificate or endorsement in ESL instruction, 7= attended or presented at a conference related to multicultural education or CRT, 8= attended or presented at a workshop or training about multicultural education or CRT, 9= ever had a practicum student or student teacher, 10= guide or instruct practicum students or student teachers on CRT, 11= check over or evaluate practicum student lesson plans for CRT, 12= had a practicum or student teacher from a different racial or ethnic background, 13= number of practicum students from a different racial or ethnic background. **p < .01, two tailed *p < .05, two tailed

The results from the mean and standard deviation of the survey scores show that overall teachers are minimally implementing CRT practices (See Table 1). The CRT practices that teachers are doing most are more general in nature than the ones they are doing less, which are more specific to considering individual student identity and culture. The results for research questions two and three indicate that students' demographics influence teachers' implementation of CRT practices more than the teachers' own demographics and characteristics. Teachers that have Hispanic students may be more likely to implement CRT practices. The number of African American and Asian students also may influence teachers' implementation, but only with a few CRT practices. Many just use the use supplemental materials to teach ELLs. None of the teacher demographics seem to significantly impact whether they implement CRT practices. The only significant correlations were for the teacher characteristics "guide practicum students on CRT", and "check over practicum students' lesson plans for CRT." Thus, the level of education, professional development, and race or ethnicity of the teacher did not seem to influence their CRT implementation.

Discussion and Conclusion

The results reveal that the practices teachers are doing the most are more general in nature and may be based on self-perception. For example, two of the highest scored items, "Reflect on my teaching," and "Provide a fair amount of attention" are self-evaluation items. While the highest scored items are essential facets of CRT, they alone do not encompass truly implementing CRT. The items that scored the lowest were more concrete, pointing to observable practices specific to CLD students, such as "Greet ELLs," and "Explicitly facilitate conversations about unpopular or taboo topics." Hence, Central Illinois teachers are more consistently implementing practices of CRT that are less specific to CLD students, and more related to good teaching practices in general. Results shows that majority teachers are not ware or unfamiliar with elementary of CRT framework such as lack of critical consciousness about cultural diversity. Perhaps a reason that teachers scored lower on certain items and not others is because of the student demographics of their class. Low number of ELLs, less than five, except Hispanic students (25.16 %) and 66.365 teachers have no ELLs in their classrooms. This supports the results of the study that there was a correlation between student demographics and teacher implementation of CRT.

There were significant correlations between teacher CRT implementation and the number of students that were Hispanic. These results suggest that within Central Illinois, teachers are more likely to implement CRT practices when they have a higher number of Hispanic students. Further, the CRT practices that teachers with these students implement are specific to being inclusive of CLD students, such as analyzing materials for lack of or misrepresentation of diverse populations, evaluating the appropriateness of assessments, and helping students identify where they fit into the school culture.

There was no of correlation between the other student demographic variables, such as number of White students, grade level, or number of new students with teacher implementation of CRT. This may signify that teachers without a population of diverse students in their class may not see a need to implement CRT practices, especially ones that are specific to analyzing materials and instruction for inclusivity and consideration of diverse populations. This inference further supports why the items that were more general, almost expected practices of good teachers despite class makeup, were among the highest scores. Subsequently, it seems that the less diverse the class population is, the less likely the teacher is to use CRT practices that are specific to being inclusive of varying aspects of culture or diversity. Among one of the lowest scoring items was "Greet ELLs in native language." Though this was one of the lowest, it is possibly because majority of the sample (66%) did not have ELLs in their classrooms. Teachers that did have many ELLs show that there was strong correlation with CRT implementation, especially with practices that are inclusive of CLD students.

Practices that had no correlation between student demographics also had low scores by the whole sample were collect information about students' interest and learning preferences to guide instruction, data about parents' cultural practices and preferences, and identify the ways in which school culture and expectations are different than students.

Teachers that do not implement CRT may have a superficial understanding of multicultural education or CRT practices in general, and thus may not have the self-efficacy or motivation to implement it, which aligns with research from Fry et al. (2010) that points to self-efficacy being a determinant factor for CRT implementation. Another reason may be that teachers simply do not see a need or want to implement it, especially the facets related to talking about and including diversity in instruction, which could be related to the social hierarchy and how the community and school is structured around the dominant society (Gay, 2018).

It is understandable that primarily White, rural schools (majority of the sample) have instruction and curriculum that is conducive to that population; it would be expected since that is what works for those students. On the contrary, administrators and teachers also need to supplement the curriculum and instruction with aspects of culture and diversity to advance global and cultural awareness and competence that precedes a diverse, accepting, and equitable society. Consequently, administrators or teachers that do not recognize a need to supplement the curriculum and do not, may be continuing to perpetuate social constructs that favor the idea of White privilege and thus inequalities for diverse populations. It could also be that their own biases (Gay, 2018) or unwillingness to confront the concepts of White privilege and dominance that may prevent them from implementing CRT or multicultural education.

Another possible reason teachers may not implement CRT is because they believe in the colorblind paradigm, which is where students are viewed as the same, despite race or ethnicity (Gay, 2018). Overall, teachers that have higher numbers of certain diverse students, such as Hispanics students, implement some CRT practices on a more consistent basis than teachers who do not have those students. There was no correlation between teacher demographics and implementation of CRT practices. As a result, the years of experience, an ESL endorsement, highest education earned, and professional development specific to CRT and multicultural education do not seem to influence if a teacher implements CRT. Only the two characteristics of "guide practicum students on CRT" and "evaluate practicum students' lesson plans for CRT" correlated with teacher implementation of CRT. These two teacher characteristics had a correlation with every CRT item on the survey.

The component of teacher professional development had a higher correlation with the CRT practices. However, it is not evident that if a teacher is Hispanic, she will implement CRT more than White teacher. Therefore, when examining the true demographic of the sample, there was no correlation with CRT implementation. There are two possible reasons for this finding; one is lacked quality professional development on CRT and two, even the professional development was comprehensive and good quality, some teachers may not feel compelled to change their instruction and have resistance or disagreement with the new information.

For the study, the researchers viewed the characteristics as components of professional development related to CRT, so the items were placed within the teacher demographic category; however, it is reasonable to conclude that these two characteristics had a higher correlation with the CRT practices because they are also forms of CRT practices. It is cogent that the more a teacher implements CRT, then the more likely they are to instruct a practicum student on it and evaluate their lesson plans for it. In contrast, based on the results, it is not evident that if a teacher is Hispanic, she will implement CRT more than a White teacher. When examining the true demographics of the sample, there was no correlation with CRT implementation.

Varying reasons could be the cause of these findings. A possible explanation why professional development does not influence teacher implementation of CRT is a lack of quality professional development around CRT. If the quality of the professional development was not comprehensive nor provided the necessary skills surrounding CRT theory, then the teacher may not feel confident in implementing it because they do not have adequate knowledge or the skills to do so (Frye et al., 2010; Gay, 2018; Plata, 2011; Tran, 2015).

The findings of the study may give insight to administrators in how they can more appropriately meet the needs of CLD students in their schools and improve student achievement through changes in policy and procedures. Administrators may learn that they need to consider the types of assessments that are used for student placement measures in English as a second language and special education services as well as the validity of standardized assessments. The findings may also prompt administrators to contemplate how they are evaluating teachers' effectiveness and include evaluation measures specific to meeting CLD students' needs. The evaluation of teachers' effectiveness specific to CLD students may prompt administrators to increase professional development requirements or opportunities for themselves and teachers to enhance their knowledge of assessment and curriculum for CLD students. In addition, they may learn they need to work to create an overall more inclusive and representative school environment and climate. If administrators were to consider all the implications from the study, then CLD student achievement may have better likelihood of improving.

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Middle School Students' Spatial Engagement in
Design-Based Integrated-STEM Activities
by
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Abstract

This article explores the spatial-reasoning skills of rural middle school students as they engage in design-based integrated-STEM activities within a makerspace setting of an afterschool program. Spatial reasoning was selected because of its pervasive influence across all STEM fields. A qualitative multiple case study research design was implemented. Eight middle school students enrolled in an after-school STEM program participated in this study. Data sources include spatial-reasoning worksheets, in-class observations, audio-visual screen recordings, design journals, semi-structured interviews, and 3D-printed design artifacts. A within- and cross-case analysis found that design-based spatial engagement is multifaceted involving the individual, the activities, and the community. Findings of this study have meaningful implications for structuring and scaffolding design-based pedagogies in STEM teacher education programs and for professional development of classroom teachers. Recommendations for future research are discussed.

Over the last few decades, efforts have been made to increase student interest and retention in Science, Technology, Engineering, and Mathematics (STEM) in the United States and across the world. When looking for the determining factors for students' STEM success, it has been found that a strong mathematical foundation is one of the critical components (NCSM & NCTM, 2018). Under the umbrella of 21st-century skills (P21, 2014), there are a series of imperatives for student success in STEM fields such as reasoning using evidence, critical thinking, building creative solutions, problem-solving, and collaborating with peers (Alonzo & Ke, 2016; Wertheim, 2016). However, the recent Nation's Report Card revealed some alarming findings (NAEP, 2023). Specifically, it showed a significant decline in math scores for fourth and eighth grades children compared to the 2019 assessment data. This decline is further exacerbated by the learning loss that has occurred due to the COVID-19 pandemic (Donnelly & Patrinos, 2022). Consequently, classroom teachers are confronted with two major problems: recruiting student interest by making mathematics engaging and addressing the learning gaps that may have occurred during the COVID-19 pandemic. An integrated-STEM educational model embedded within design-based learning is a promising solution as it can potentially interweave two or more disciplines by targeting cross-curricular standards and real-world applications (Ke, 2014; Sanders, 2009).

Literature Review

The STEM 2026 vision for innovation seeks to create an equitable and culturally relevant integrated STEM curriculum by connecting six key components: engaged and networked communities of practice; accessible learning activities that invite play and risk; educational experiences that include interdisciplinary approaches to solve grand challenges; flexible and inclusive learning spaces supported by innovative technologies; innovative and accessible measures of learning; and societal and cultural images and environments that promote diversity and opportunity in STEM education (U.S. Department of Education, 2016). In alignment with the STEM 2026 vision, design holds potential to fulfill the objectives of integrated-STEM education programs by developing transdisciplinary content knowledge essential for solving real-world problems in the 21st-century (Li et al., 2019; Zhou et al., 2020).

Design-based learning (DBL) is an inter-disciplinary approach where students experience stages of developing, reviewing, revising important ideas and structures in an authentic real-life context compared to traditional lecture-based STEM classrooms (Li et al., 2019). DBL is based on a social constructivist theoretical framework influenced by situated cognition (Lave & Wenger, 1991), experiential learning (Dewey, 1938), and social interaction (Vygotsky, 1978). Learning activities in DBL are often model-eliciting-activities, constructed in such a way that the students experience the design thinking process (Weng et al., 2023). The design pathways have resulted in higher student outcomes as students are involved in active construction of STEM-content knowledge, developing deeper conceptual understanding, and collaborating with their peers (Asempapa & Love, 2021). On the contrary, artificial and decontextualized tasks do not help K-12 students to make sense of their learning (National Academies of Sciences, Engineering, and Medicine, 2019). In this study, design-based integrated-STEM activities were chosen within the mathematical domain of spatial reasoning.

STEM fields are visually intensive (Lamb et al., 2018; Smith, 2018). Therefore, being able to imagine and pictorially represent complex systems in two-dimensional and three-dimensional spaces is necessary especially in mathematics and engineering disciplines (National Research Council, 2012). Having spatial-reasoning skills are essential for attaining geometric thinking, number sense that are highly valued in the interdisciplinary STEM fields (Baki et al., 2011; NCTM, 2000; National Research Council, 2012). It needs to be noted that spatial reasoning is not an innate ability that only a few students have. Spatial reasoning is malleable and could be taught through appropriate interventions (Uttal et al., 2013). Past research done among teachers and students has measured spatial reasoning using standardized quantitative instruments (Baki et al., 2011; Lamb et al., 2018; Otumfuor & Carr, 2017). However, the current study looked at the qualitative aspects of spatial reasoning as a training of spatial-reasoning skills through rich interactions between people and environments (Xie et al., 2020).

Design-centered curriculum is still in budding stages in K-12 education. Most of the teachers have not experienced it in their pre-service training. Inadequate opportunities for professional development hamper the content specific knowledge that teachers require in integrated-STEM classrooms (Corlu et al., 2014; English & Mousoulides, 2011; Herro & Cassie, 2016; Ryu et al., 2019). Hence, teacher professional development is relevant. In addition, DBL implementation requires time as it relies heavily on hands-on activities, modeling, learning from failures, and personal reflections (Dickson et al., 2021). This can be a challenge under the current standard-based testing pressures and accountability. Besides, teacher’s implementation of these integrative approaches highly depends on their individual characteristics when adapting new instructional methods, their perceptions towards the integrative approach, school context, geographical location, delivery methods, and their own categorization of students who they perceive would be successful in STEM areas (Becker & Park, 2011; Lesh & Doerr, 2003; Peterson, 2020).

Accordingly, the present study was set within a rural school district, which is often underserved with design-based STEM interventions that require adequate funding. Incorporating free open-source CAD tools like Tinkercad® could provide equitable resources to underserved school districts. Therefore, the results of this study would be useful for school administrators to know what support and resources are needed for ensuring mathematical achievement in middle school. Also, the outcomes of this study would be useful to plan and incorporate design centered STEM professional development workshops for interested teachers (Baker & Galanti, 2017; Banilower et al., 2018; Cairns et al., 2018).

Methodology

The purpose of this qualitative multiple-case study was to investigate how middle school students engage in design-based spatial reasoning activities in a rural educational setting. The study aims to inform curricular changes that potentially could be implemented in teacher education programs. A case study was suited for this research because case studies aim to understand a particular phenomenon such as a program, process, event, organization, or concept in the social context of schools (Creswell & Poth, 2018; Efron & Ravid, 2020). The present study was conducted as part of a twelve weeklong after-school STEM program that used design-based STEM modeling activities as the central phenomenon or bounded case (Yin, 2009). *Tinkercad®* (see also www.tinkercad.com), an open-source three-dimensional computer-aided design tool, was used to design different integrated-STEM modeling activities.

Participants in the study were middle school students in a rural school district in southern mid-west belt of United States selected through purposive sampling. There were three students at beginner level (completed less than one year in the afterschool program), two at intermediate level (in year two of the program), and three at advanced levels (in year three of the program). Data for this study was collected from in-class observation field notes, practitioner (principal investigator) reflection journal entries, the spatial reasoning worksheets, middle school children's design artifacts, and semi-structured interviews with selected middle school children and their classroom teacher. For case studies, multiple sources of data such as interviews, observations, documents, and artifacts are best suited as it provides extensive information of the cases and their specific context (Creswell & Poth, 2018). The typical class time was 120 minutes. In a week, there were two class sessions with different cohorts. Each cohort was given three design challenges within specific constraints: (1) design a Rubik's Cube, (2) design a bird feeder, and (3) design an inclusive playground.

Data analysis procedure for multiple-case studies typically starts with a within-case analysis of individual cases followed by a cross-case analysis (Creswell & Poth, 2018; Yin, 2009). During the within-case analysis, I read each participant's design journal entries for the three design challenges. I highlighted key words that represent spatial discourse using a highlighter pen. In the side margins, I wrote down in-vivo codes of my first impressions. I repeated this process for the three design journal entries. I did a second cycle of focused coding to refine the code names. I looked for repetition of words or ideas in the in-vivo codes until saturation. I grouped the codes into eleven categories and organized overlapping categories into three main themes. To ensure trustworthiness, I triangulated data from multiple sources, provided rich and thick description of each case, and kept a record of research decisions and interpretations in my researcher memo.

Findings

Findings revealed that student engagement in design-based spatial reasoning tasks is multifaceted involving the individual, the activities, and the community. While engaging in the design challenges, most participants made connections with their own individual experiences and interests. For example, Student A mentioned that the Rubik's Cube design challenge reminded him of cube puzzles. He related bird feeders to one at his aunt's place and a local park as inspiration for the inclusive playground design. Student E reported similar observations. His bird feeder design was adapted from "planes in the sky to protect a country." Student H noted that his bird feeder design reminded him of one at his neighbor's house. Student F associated his bird feeder design with a pine tree. Hence, connecting with familiar objects, personal interests, and prior experiences was common among most participants.

Learning through play and wonder was emphasized throughout the design cycle. In the design journals, participants wrote about their wonderings that led to their designs. For example, Student G wondered, "if the space I gave the axis will be enough to allow it to spin." This wondering led Student G to examine the interior of an actual Rubik's Cube to compare the distance between the connected pieces. In another instance, Student E wondered if his design solution would work in real-life. The ambiguity that arose from such wonderings led him to critically analyze and acknowledge the limitations of his design solution during the in-class presentation.

The Activities

"Perceived task difficulty refers to one's beliefs regarding how much effort would be needed to succeed at a task, and whether success is even possible" (Horvath et al., 2006, p. 171). I found that the initial response of seven out of eight participants upon encountering the design challenge was to categorize them as either easy, medium or hard. The participants noted several reasons for such categorization in their design journals. For instance, the beginner level and intermediate level students found it difficult to symmetrically align the Rubik's Cube pieces into three layers and to put the correct colors on the cube faces. Whereas the advanced level participants were mostly concerned with getting the Rubik's Cube to spin. Student C wrote, "it is hard because the cube was hard to put together." On the other hand, Student E noticed that the task was easy, however, he wondered about how it spins. For the bird feeder design challenge, most participants said that the difficult part of the challenge was to make it squirrel proof. Similarly, for the inclusive playground design challenge, Student B noted that "it's hard to make the playground look accurate". Student B clarified that space can be an issue to place the playground equipment side by side considering the need to add ramps.

I observed that participants were more motivated to produce design solutions when they perceived the task as relevant for real-world contexts. Of the three design challenges, majority of the participants found Rubik's Cube to be the least relevant. Conversely, I found the bird feeder challenge to be more popular, as participants recognized the importance of making a squirrel-proof due to their rural geographical location. Most students expressed empathy for the need for an inclusive playground in their schools, particularly for accommodating their wheelchair bound classmates who were left out during recess hours. Student E suggested that the playground equipment should be tactile-friendly and quiet for those who prefer a low-noise environment. In addition, participants associated task relevance to cross-curricular connections. Student H mentioned how engaging in Tinkercad® environment helped him to understand geometry and area concepts.

Seven out of the eight participants engaged in collaborative learning. When challenged by the design tasks they preferred to work together in refining their ideas. However, Student A made a distinction between working together and copying another's work. It is worth noting that Student A is self-driven to seek a unique solution.

> Researcher: Do you like to work with others or by yourself when you do your design challenges?

> Student A: I think I would rather work with others just to help if I do not know what I feel like. It is easier to see what they are doing. It is just kind of not like copying but like trying to help instead of trying to see if it would help with my work.

When prompted for an example of how friends help in the classroom, Student B responded, “when I was trying to figure out how to loosen up like how to align [cubes] because I forgot, Student F and Timothy [pseudonym] helped me”. Navigating Tinkercad® can be a challenge for first time users. Having an avenue for collaborative learning is beneficial to reinforce learning. However, two students (Student D and Student H) did not always favor collaborative learning. Both agreed that engaging in collaborative learning depends on the task. For example, Student H’s opinion on collaborative learning is

> I like to work by myself except for projects that need research or where I have a part to play. But I do not want anybody to tamper with my vision. I [would say] yes to work with others because [for the Rubik’s Cube] I had the core piece… because it was a six sided cylinder thing so that was easy for me. Since we were working by ourselves, myself, technically, I just had to give out measurements [that] I did not really mind.

Discussion and Implications

Research Question: How do middle school students engage in design-based spatial reasoning activities in a rural educational setting? Adding personal interest elements was beneficial to transfer prior experiences to a virtual makerspace. This aligns with recruiting interest policies under the universal design for learning framework (CAST, 2018). During student presentations, participants shared stories from their personal experiences to add authenticity to the proposed solutions, consistent with the findings of Hidi and Renninger’s (2006) study on interest development and its sustenance. Participants were found to be intrinsically motivated to persevere in the tasks. This may also be due to the possibility of creating and procuring a 3D-printed model of their solutions as a reward based on self-determination theory and reward system (Ryan & Deci, 2000).

Active wonder is built on curiosity and desire to understand how and why something works (Schinkel, 2017). Similarly, play is vital for the development of children’s conceptual understanding and critical thinking skills through hands-on and minds-on explorations (Pyle & Danniels, 2017; Vygotsky, 1967). In a related study, Wolbert and Schinkel (2021) found that regular classes do not usually provide enough opportunities for wonder and play and consequently students had to rely on guessing to find the right answers based on their learned procedure. Research shows that play-based learning is often emphasized in the early childhood and elementary schools and not as much in secondary schools (Bubikova-Moan et al., 2019; Jay & Knaus, 2018). Mainstreaming play and wonder into the middle school curricula seem to be crucial for success in design-based spatial reasoning activities.

Perceived task difficulty may pose a hindrance to learning when students express fixed thinking (Boaler et al., 2021; Dweck, 2006) about difficulty of a task. Consequently, students are not motivated to attempt or complete the task. It was observed particularly in Student C’s responses where she perceived all tasks as hard and could not complete any of the design challenges. This finding is consistent with Nunan and Keobke (1995) where they found that students’ successful task completion rate was low as there was a significant measured difference between the learner’s perceived task difficulty and the actual task difficulty. On the contrary, the Rubik’s Cube challenge appeared to be most engaging even when categorized as the hardest of the three design challenges. Participants chose it as the design challenge that they were most proud of even when they couldn't fully accomplish the spinning mechanism constraint. This is consistent with Lavrijsen et al. (2025), where the researchers found that students with high cognition needs showed increased levels of engagement even in difficult math classes.

An alternative interpretation for Student C's responses could be that as there was no credit or grade associated with the completion of the design challenge, the intrinsic motivation to complete the task decreased (Scasserra, 2008). The motivational theories such as expectancy-value theory (Wigfield & Eccles, 2000) and flow theory (Csikszentmihalyi & Csikzentmihaly, 1990) advocate providing learning tasks that are neither hard nor easy, rather somewhere in between for the learner to be engaged. Therefore, the nature of the tasks may have influenced the results of the present study especially with respect to time constraints (Bufasi et al., 2024).

In the present study, most of the participants were interested in understanding if their design solutions would work in real-life. This is maintained by the situated-expectancy-value theory where learning is motivated by personal meaning and utility value of the task influenced by culture and contexts in which the individual is situated (Eccles & Wigfield, 2020). Here, utility value refers to finding learning tasks as relevant. The predisposition of task relevancy may be subjective as it can vary with the individual's present or future goals (Eccles & Wigfield, 2024). Furthermore, majority of the participants connected the practical significance of their design challenges to math, science, and engineering concepts. Some of them acknowledged that cross-curricular skills obtained would be beneficial for their future STEM careers. This is in line with research studies that found that design pedagogies foster STEM career readiness (Carroll, 2015; Gibson et al., 2021; Li et al., 2019).

Open-ended problems are often connected to real-world everyday problems. Therefore, for effective problem solving, collaboration with members of the community may be essential. In such collaborations, affective factors are involved as groups of learners are physically close to one another (Jones & Issroff, 2005). In the collaborative setting, there is usually a willingness and mutual respect to work together as participants listen, negotiate, and reach agreements (Morado et al., 2021; Stevenson et al., 2019). In the present study, although group work was not assigned by the researcher, participants chose to form their own *maker niches* or maker groups in the classroom. Mostly, this was through pre-existing friendships among the participants. The group members interacted with one other seeking opinions and refining their individual design ideas. In addition, there were participants who chose to work independently unless they were responsible for a critical piece of the group's work. However, there is not enough evidence to conclude if such preference for independent task execution is due to fear of losing control. Research shows that losing control over tasks can make some learners uninterested or demotivated (Jones & Issroff, 2005). Therefore, the basic psychological needs of the students such as autonomy, relatedness, and competence must be met to keep the learner engaged (Deci & Ryan, 2000).

Although collaborative learning produced rich discussions around multiple solutions, participants were not technically knowledgeable to estimate the feasibility of their design pathways. Lack of technical expertise on the part of the teachers or facilitators could be a barrier when it comes to advanced design challenges, which could affect the sustainability of the design-based learning approach (Delen et al., 2020; Xiao et al., 2022). For instance, Ayse Tugçe and Mevhibe Kobak (2024) mentioned that majority of prospective math teachers perceived the Tinkercad® program as time-consuming to learn. This points to the growing need for training opportunities for both in-service and prospective teachers.

Implications for Practice

There are several implications for teachers, teacher educators, and school administrators. Teachers may include design-based open-ended problems by carefully selecting design challenges that are grade-appropriate and set in authentic contexts. Teachers may need peer support from colleagues who has expertise in other content areas. Teachers may form a professional learning community to learn new technical skills and experiment them in their own class rooms as short-term research projects. This will pave way for them to become teacher-leaders in their own community to advocate evidence-based design-based pedagogies. Teacher educators may consider adopting design-based pedagogies as part of their instruction so that pre-service teachers are better prepared for 21st century learning demands. Moreover, the after-school setting of this study brought together other community members such as university faculty, undergraduate and graduate students from STEM and non-STEM fields. Teacher educators may partner with school districts using this practice-grounded model by conducting professional development workshops. School administrators can provide a space for such partnerships through industrial visits and field trips by connecting with other community members such as engineers, scientists, artists, and mathematicians.

Recommendations and Conclusion

This study identifies several promising directions for future research. First, the study has adopted a qualitative methodology unlike most studies that relied on a quantitative methodology using various standardized instruments that measure spatial reasoning construct. I recommend that future researchers use a standardized spatial reasoning instrument and employ a mixed methodology to investigate both the quantitative and qualitative aspects of design-based STEM education. Secondly, future studies may consider using a pre-test-post-test experimental design to know if the results of the study are due to the intervention or not. Third, researchers may consider using emerging technologies such as virtual reality and augmented reality for 3D modelling and other 3D modeling tools like SketchUp for generalizability.

In conclusion, this study shed light on middle school students' spatial reasoning skills in a makerspace environment. It showed the power of design for student engagement in STEM education, showcasing design-based mathematical learning in integrated-STEM education. This points to the need for further pedagogical innovations in rural STEM education through multifaceted engagement.

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Predictors of Retention in STEM Teaching within a STEM Scholarship Program

by

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Abstract

This study examined predictors of retention among STEM teachers who participated in a STEM scholarship program at a rural Texas university. Using mixed methods, the researchers analyzed six quantitative metrics (beginning GPA, ending GPA, SAT scores, credit hours, time to graduation, and transfer status) and four qualitative traits (motivation, teachability, prior experience, resilience and challenges). No metric reliably predicted retention, though candidates who anticipated challenges and reflected on emotional resilience demonstrated slightly higher persistence. These findings raise questions about the validity of traditional selection metrics for STEM teaching incentive programs and suggest broader recruitment strategies may strengthen the STEM teacher pipeline.

Teacher shortages, especially in the areas of science, technology, engineering, and mathematics (STEM) are a global issue (Nguyen et al., 2024; Aragon, 2016; Han & Hur, 2022; Loveless, 2022; Sutcher et al., 2016). Reports have shown that the Covid pandemic exacerbated these shortages, lowering morale and straining an already tenuous teacher supply (Bartlett et al., 2024; NEA, 2021; Ward, 2022). A lack of qualified teachers and high teacher turnover negatively affect students directly, diminishing the level at which nations compete, particularly in the STEM fields (Carver-Thomas & Darling-Hammond, 2019).

One solution to the teacher shortage problem is to recruit and train more qualified teachers. However, training those new teachers is challenging and costly, with some estimates indicating the cost to be seven to eight billion US dollars annually (Carroll, 2007; Darling-Hammond, 2010; Sutcher et al., 2016). Research shows that around half of all teachers change careers, or find alternative employment within 5 years (Aragon, 2016; Ingersoll & Smith, 2003; McCallough, 2021). This attrition is especially problematic in STEM since highly talented teachers are among the most likely to leave (Guarino et al., 2006).

Given the tremendous implications for recruiting and training STEM teachers who will persist in the field, it is reasonable to attempt to identify STEM teacher candidates with the most promise for success. This study examines the following research question, “Within an incentivized STEM teacher preparation program, how do gatekeeping metrics and characteristics associate with retention in STEM teaching?”

STEM Teacher Recruitment Incentives

The United States spends billions of dollars recruiting prospective teachers specifically into high-need teaching areas, particularly STEM. These efforts predominantly seek to attract the “best and brightest” into teaching. Since 2007, the U.S. Department of Education has offered the TEACH grant – scholarships in exchange for a commitment to teaching for four years in a high-need field (Zeta, 2024). The grant generally requires that recipients be in the “75th percentile on one or more portions of a college admissions test or [maintain] a cumulative GPA of at least 3.25” (Federal Student Aid, 2025). Since the start of the program, the TEACH

Grant has awarded over $1.3 billion, funding over 400,000 scholarships. However, for the period of 2008 to 2018, only 12 percent completed their full four years of teaching service (Zeta, 2024).

Another federal program, the Robert Noyce Teacher Scholarship Program, created in 2002, provides scholarships and support for aspiring STEM teachers in exchange for a commitment to teach STEM in a high-need district. As of 2021, the program had invested over $1.2 billion into recruiting and equipping STEM educators (Feng et al., 2021). Individual projects are allowed to set their own admission criteria but admonished to select candidates “primarily based on academic merit” (National Science Foundation, 2025). Yet another highly publicized incentivized recruiting program for students from highly regarded universities to teach in high-need classrooms is the Teach for America program. Research indicates these teachers are effective, but that most exit the profession after 2-to-3 years (Boyd et al., 2006; Xu et al., 2011).

Many state governments also actively fund recruitment of new STEM teachers. Espinoza and colleagues (2018) documented more than 40 state-level incentive programs to attract prospective teachers, including a focus on STEM. In 2017 alone, Wilson and Kelley (2022) documented 47 bills passed in 23 states to actively recruit teachers.

Researchers have worked to examine the effectiveness of exclusive scholarship programs given their high price tags with mixed findings. Henry and colleagues (2012) examined a large merit-based scholarship program and found that the program produced teachers that stayed in public school classrooms at a higher rate than “traditionally prepared” or alternative entry teachers but taught different student populations. According to the work of Kennedy (2010), policy makers and educational researchers may be overestimating the effects of teacher’s personality traits on their students’ learning in an effect called attribution error. Studies such as Feng and Sass (2015), and Bardelli and Rondfeldt (2020) have also sought to compare the teaching outcomes of students from highly selective scholarship incentive programs against other teachers entering the teaching field. However, by design, these studies do not account for the possibility that the very fact that students applied for such programs might be a dominant characteristic overshadowing their academic merits. We sought to use a different approach. Based upon this review of research findings about incentive programs for STEM teachers, this study seeks to understand *within* an incentive program how six quantitative metrics (beginning GPA, ending GPA, SAT scores, credit hours, time to graduation, and transfer status) and four qualitative traits (motivation, teachability, prior experience, resilience and challenges) associated with retention in the STEM classroom.

Context for the Study

Talented Teachers in Training for Texas (T4) at Stephen F. Austin State University (SFA), funded by the National Science Foundation’s Robert F. Noyce Teacher Scholarship Program, is a scholarship focused grant that recruits, trains, and supports aspiring STEM teachers to teach in high-need districts. Teacher candidates were actively recruited at the primary university site and at eleven community college sites. Scholars were required to be majoring in a STEM field, have completed at least 60 college credit hours, have at least a 2.75 GPA, be US citizens or permanent residents, and be on track to graduate within 2.5 years of beginning the program.

Candidates applied online. Finalists were asked to attend a face-to-face interview with two faculty members and a T4 Scholar within the program. Once selected for the program, T4 Scholars attended biweekly workshops and community-building activities. Activities varied from discussions of designing cohesive semester-long lesson plans, to visits from area principals, to book studies held at a coffee shop. T4 Scholars were awarded scholarships of roughly $15,000 per year, covering tuition and some of their living expenses. (Tuition and fees were roughly $10,000 per year during the course of this study.) The scholarship recipients commit to one year of teaching STEM in a high-need school district for each semester they receive the scholarship. If they do not fulfill that commitment, they must repay the scholarship.

The T4 program at SFA has had notable success in graduating certified STEM teaching majors. Since 2012, T4 has funded 44 STEM majors to become T4 Scholars. Of the 44, 100 percent have persisted to graduation and teacher certification, compared to a 19 percent graduation and certification rate outside the program (Hubbard et al., 2019; Hubbard et al., 2021). All 44 STEM majors who applied for, were awarded, and chose to accept the T4 Scholarship were included in the study.

Common Gatekeeping Metrics Used for Recruiting into STEM Teaching

Grant-funded projects entrusted with the recruiting and training prospective STEM teachers work to select the candidates most likely to succeed and remain in the classroom. This study examines STEM teacher retention in-the-field in relation to the following 10 features: entering GPA, ending GPA, credit hours, years to graduation, SAT, transfer student status, motivation for entering, teachability, prior experience educating, and challenges and resilience.

Grade Point Average (GPA) is a leading criterion for selecting students to teacher-education programs (Haberman & Post, 1998; Hall & West, 2011; Mikitovics & Crehan, 2002), perhaps for its availability or for the belief it predicts academic success (Noble & Sawyer, 2004; Sawyer, 2013). Methodologies for calculating GPAs vary, but generally they are a weighted average of all grades assigned during a particular course of study - usually either throughout high school or throughout college. For our study, we considered two different calculations of GPA – the first being the weighted average of college grades at the time of acceptance into the T4 program (called the *Entering GPA*); the second being the weighted average of college grades at the time of graduation (called the *Ending GPA*). Ending GPA is not purely a ‘gatekeeping’ metric, it might well depend on the program itself but was a feature of interest. *If* it correlated to teacher retention, efforts might be made to ensure candidates were chosen to maximize ending GPA.

Credit Hours are central to student progress throughout a university degree. Having a high number of credit hours is highly predictive of graduation (Aiken et al., 2020). It also indicates that a student is closer to beginning their professional career and might reasonably have considered career implications more seriously. We considered the number of credit hours students had at admission to the T4 program, which aligned with the timing of their commitment to teach in a high-need district.

Years to Graduation is a measurement of succeeding or ‘excelling’ at college. Delays can have negative implications for both completing college and starting a career (Marcus, 2021). Further, the age at which a student graduates has been shown to have career implications (Aina et al., 2019). We chose to examine the time from acceptance into the T4 program to graduation with a STEM degree.

Standardized Test Scores (ACT / SAT) have long been employed as predictors of college success. Research by Coenen and colleagues (2018) indicates that a teacher’s standard testing scores appear to positively correlate with their student’s math performance. Yet, while there is some evidence that teachers with strong scores are better at teaching (at least in mathematics), other research has indicated that teachers with higher test scores seem to be more likely to leave the teaching profession (Guarino et al., 2006). In contrast, Borman and Dowling found that teacher attrition rates were higher “among those who ... scored relatively lower on some standardized tests” (2008, p. 396).

It is well documented that *Transfer Students* have different university experiences than those who began at a four-year institution. Xu and colleagues (2018) found that while Virginia transfer students had a comparable likelihood of earning a bachelor’s degree, they faced a “transfer penalty” that manifested in lower earnings. On the other hand, the National Association for Law Placement (2019) found that transfer students who completed law school degrees were *more* likely than student who started at four-year institutions to be employed after graduation and to secure positions in large firms.

Motivation for Entering STEM Teaching and pursuing the scholarship was a non-numeric characteristic the study considered for teaching persistence. Watt and colleagues (2007) examined 12 motivations for entering STEM teaching and concluded that targeting prospective STEM teachers’ motivations would be a best practice in recruiting an enduring STEM teaching workforce. Altruistic motivations, followed by intrinsic motivations, seem to be the primary motivations of teachers and an indicator for pre-service teachers who are engaged during the teaching program and stay in the teaching profession (Jungert et al., 2014).

Teachability, or a positive response to feedback was also considered. Effective feedback itself is well understood to improve performance (London, 2014; Sendziuk, 2010; Visscher & Coe, 2013). However, a willingness to receive this feedback is needed. This study examined *articulated* teachability, that is scholarship applicants stated willingness or desire to receive instructive feedback. Crommelinck and Anseel (2013) explored the importance and function of feedback-seeking behavior. They stated that feedback-seeking behavior is an important factor for learning and improving performance in individuals. The study examined if and how articulated teachability in students related to teacher persistence.

*Prior Experience e*ducating others gives a realistic view of whether the profession is a good match. Sarwat and Bashir (2024) found that, in *any* line of work, providing prospective employees with realistic information during recruitment decreased turnover. Specifically in STEM teaching, Luft and colleagues (2005) found that prior tutoring experiences, or similar experiences, leads to greater commitment and dedication to becoming science or mathematics teachers. Fortner and colleagues (2015) documented how teachers who first served as teaching assistants were retained at high rates despite have lower average licensure exam scores.

Challenges and Resilience constituted the final feature that this study examined in participants. The extent to which individuals recognized adverse situations, and adapt well, is critical for the long-term success of teachers (Arnup & Bowles, 2016; Ng et al., 2018). Multiple adversity studies have examined ability to withstand developing negative physical and mental health outcomes (Alarcon, 2011; Fernet et al., 2012; Swider & Zimmerman, 2010). Teachers are exposed to many stress factors including large classrooms, poor working conditions and large workload, conflicts with parents, problematic student behavior, and other stressful factors (Aldrup et al., 2018; Baeriswyl et al., 2021; Dicke et al., 2018). In their study on resilience and teacher attrition, Arnup and Bowles (2016) found that teachers with lower levels of resilience also showed higher intentions of leaving the profession, which held true even after controlling for other factors.

Conceptual Framework and Methodology

Research within social settings such as educator preparation is complex. Student characteristics and dispositions such as the “big five” personality traits that might influence students' benefit from their educator preparation are impossible to "directly measure." A nuanced examination of these issues lends to a qualitative naturalistic inquiry research design. Erlandson and colleagues stated, "The aim of naturalistic inquiry is not to develop a body of knowledge in the form of generalizations that are statements free from time or context. The aim is to develop shared constructions that illuminate a particular context and provide working hypotheses for the investigation of others" (p. 45, 1993). The authors and researchers involved in this study have been working within the context of this study for over 10 years, and this study was born out of their theoretical sensitivity (Glaser & Straus, 1967) and long-term engagement (Lincoln & Guba, 1985) with the project.

Throughout 10 years of research, the authors have engaged in the constant comparison method of data analysis (Glaser & Strauss, 1967) for data artifacts, developed research presentations, published peer reviewed research journal articles, and consistently sought answers to new questions and challenges through the use of grounded theory (Glaser & Straus, 1967). Erlandson and colleagues state "no two social setting are sufficiently similar to allow simplistic sweeping generalizations from one to another" (p. 13, 1993). As we share our analyses from over a decade, we encourage others to engage with the same type of analysis for their own STEM educator preparation programs and gatekeeping metrics (whether explicit or implicit).

The qualitative data sources were coded using constant comparative analysis (Glaser & Strauss, 1967), member checking, and code checking artifacts (Lincoln & Guba, 1985) with a faculty member who had mentored the STEM students, participated in the interviews, and also coordinated the T4 Scholarship grant activities for the students during their time at the university and beyond graduation. For a study such as this, it is appropriate to combine a naturalistic inquiry qualitative approach (Lincoln & Guba, 1985) and with descriptive statistics (Taylor, 2005) to find emergent themes occurring within the data.

Findings

Participants were divided into four groups based on outcome. *Group 1* was composed of the four scholars who were no longer teaching *and* had not met the minimum years of teaching commitment for the scholarship. *Group 2* consisted of the five scholars who had completed their teaching commitment then left the classroom. *Group 3* consisted of the 20 scholars who had met the minimum teaching requirements and were still teaching. *Group 4* consisted of the 15 participants who were still teaching but had not yet met the minimum years of teaching requirements. Although sample sizes were small, we completed chi-square analysis and Fisher's ANOVA on numeric data to assess whether the likelihood of a statistical justification for concluding that any of the metrics considered were significantly different between the four groups. Negative statistical results of this nature, without forcing a conclusion, document that there is insufficient evidence to conclude any difference exists. Groups 1 and 2 were both classified as 'leavers,' while Groups 3 and 4 were classified as 'stayers.' Utilizing this dichotomy, correlation coefficients were also calculated.

Based upon our analysis of the numeric data, the interviews, the application essays, and researcher's journals, we identified three themes within the data.

Theme 1 – The six numeric metrics did not predict whether STEM teachers would remain in the classroom.

Table 2. Gatekeeping metrics per group

	Entering GPA	Ending GPA	Entering credit hours	Years to Graduation	ACT/ SAT	Percent Transfer students
Group 1	3.41	3.49	82	2.25	--/1255	75
Group 2	3.18	3.39	86	1.70	20/1037	80
Group 3	3.46	3.37	86	2.05	23/1118	80
Group 4	3.50	3.28	86	2.27	24/1096	73
P -value	0.31	0.65	0.91	0.39	0.39	0.97
Cor with retention	0.27	-0.13	0.06	0.12	-0.04	-0.01

As seen in Table 2, correlation coefficients and an ANOVA analysis for the six purely quantitative variables were computed and provided no evidence to conclude there was a difference between groups. Significant group differences simply were not apparent. Certainly, larger populations would yield greater statistical power. But if one were to relax the level of demanded certainty to $\alpha = 0.2$, calculations of required sample size align with this study, yet none of the p-values approach this level.

We also attempted multinomial logistic regression that yielded an accuracy of 0.43 and a weighted average f1-score of 0.41. Considering the imbalanced nature of the categories, these outcomes appear no different from guessing the most common category, that would yield 0.477=21/44 accuracy.

Since all participants entered the program with a GPA of 2.75 or above, this GPA may impact the retention of the participants. But during a portion of the study period, 2.75 was the required minimum GPA of *all* students accepted into educator preparation, thus not an additional threshold. The findings of Suarez and colleagues (2021) indicate that existing disparities in opportunities for STEM majors of color often impact their ability to persist to graduation, and that the STEM majors who need more support such as financial incentives, mentoring, and a supportive STEM community are passed over for students who already have significant supports in place, and maintain the gatekeeping metrics required of most STEM majors. Our findings support this conclusion *beyond* graduation, indicating that STEM teacher persistence is personalized beyond the aggregation of metrics.

The second identified theme emerged as we evaluated our interviews, application essays, researcher's journals, to determine if non-numeric factors were predicting the participants' retention in the STEM classroom.

Theme 2 - Disposition or experience-based features did not predict retention in STEM teaching.

All students except one articulated their *motivation* for wanting to join the T4 scholarship program. Reasons varied, including financial motivations (mainly the scholarship), access to peer support and mentoring, the opportunity to attend conferences and job shadows, and having support systems (including expert faculty). However, these types of responses were fairly evenly spread across all groups. Table 3 shows the most common responses by group, with the percentage giving that response listed in parentheses. The "NASA camp" and "Job Shadowing" items refer to two different realistic job previews offered through the T4 project. The label “Task support” refers to assistance with specific tasks by people associated with the project - faculty assisting with challenging STEM content, assistance applying for jobs, etc. “Mentorship” was the label used when candidates explicitly stated they wanted ‘mentoring,’ which appeared from the context to be more focused on a caring relationship that *might* manifest in specific acts of technical assistance. Finally, financial support was labeled as “Scholarship.”

Participants’ motivation to teach was far more homogeneous. Every single applicant’s responses had intrinsic *and* altruistic characteristics. None had responses that were coded as extrinsic. One representative response was, “those teachers that were there and saying like, ‘Hey, you have a natural calling for this maybe you should think about it’” – an intrinsic motivation. The same candidate also explained how she “wanted to help the children” – an altruistic motivation. Although all responses fell into the same broad categories, much nuance also existed such as concern for specific students in specific contexts, or motivating experiences from their past. Some were effusive about their own experiences, while others wanted to serve in a way they had not been served. However, across all analyses, there appeared to be no differences that could be reduced to outcome category.

Table 3 - Most Common Stated Reason to Join the T4 Program by Group

	Group 1	Group 2	Group 3	Group 4
Most common reason	Scholarship (75%)	Job shadowing (67%)	Mentorship (45%)	Task Support (60%)
2nd most common reason	Task support (50%)	NASA camp (67%)	Job shadowing/ Scholarship (32%)	Mentorship (53%)

We also coded *Articulated Teachability* when students expressed interest in learning from programmatic components, as well as if they showed any sign of wanting to be taught or guided. One such statement was, “The opportunity to learn from faculty and connect with teachers would be an incredible experience.” Of all students analyzed, only six students did not state some form of teachability. All students in Group 1 articulated teachability. Five of six students in Group 2 (83 percent), 16 of 19 students in Group 3 (84 percent), and 12 of 14 students in Group 4 also articulated teachability (86 percent). Again, there was tremendous nuance within particular answers. Students in multiple categories expounded in details about what they wanted to learn. Others appeared to have a vague sense that they should be learning. One answer in Group 2 appeared to demonstrate a lack of teachability, despite lip service to the concept at other points. But not a single group admitted broad categorization as distinct from other groups. (We did not have data on teachability for three students in Group 3 and one student in Group 4.)

In terms of *Prior Experience Educating*, 75 percent of Groups 1 articulated some type of prior experience. One respondent described teaching in three different venues. Another described teaching extracurricular activities. Yet another simply described “teaching at a church.” Two-thirds of Group 2 students self-described as having experience teaching. One student described working in a tutoring center on campus, doing observation hours through a teaching course, and informally helping to tutor several students. Another articulated tutoring their siblings and a few peers. In Group 3, 68 percent of respondents indicated experience, and in Group 4, it was 87 percent. The most extensive experience was a Group 4 participant who had substitute taught, worked formally as a tutor, and completed a STEM teaching job shadow experience.

Analyses of both the number of students engaged in teaching activities and the intensity of those teaching activities failed to provide clear delineations between those who stayed in teaching and those who left. For instance, one Group 1 participant articulated her passion for teaching saying, “That’s where my heart is. Any age group of kids is really what I enjoy doing. I teach a group of first and second graders Sunday school. And I teach a high school girls’ Bible study.” The conversation also included her teaching of the AVID curriculum her first year out of high school. Yet she left public-school teaching after one year. Another (Group 3) participant articulated similar teaching exposure, working at a boys and girls club over summer and serving as a youth intern at a church. His outcome was quite different, completing his teaching commitment and continuing to teach (and coach) thereafter.

All outcome categories also included individuals who had no experience teaching or tutoring prior to applying for the program. All four groups also had individuals with family members who were teachers. Perhaps living with someone who is a teacher is quite realistic exposure to the profession, but again it was unpredictive of retention.

The third theme was identified by researchers related to specific challenges that might prevent students from staying in the classroom after graduation.

Theme 3 - Students perceived a variety of potential challenges, but those that articulated more challenges, possibly thought more deeply about them, were more likely to be retained. A more nuanced pattern emerged around *Challenges and Resilience*. Scholars were explicitly asked to name challenges they expected to face in their STEM degree and early teaching career. Nearly all identified at least one challenge (e.g., classroom management, emotional strain, balancing family/finances, bureaucratic constraints). Notably, scholars who articulated several specific challenges (mean coded challenges per respondent: Group 3 = 2.3; Groups 1 and 4 = 1.3; Group 2 = 1.0) tended to remain in teaching longer. This observation suggests reflective anticipation—thinking concretely about foreseeable obstacles—may reflect or foster coping strategies that contribute to persistence. (Note, however, that there was no separation between Groups 1 and 4.)

The categories of challenges coded from application essays and interviews are presented below.

- Teaching students effectively — Group 1: 1; Group 2: 1; Group 3: 4; Group 4: 4
- Nerves/being in front — Group 2: 1; Group 3: 2; Group 4: 4
- Completing program — Group 1: 1; Group 2: 1; Group 3: 4; Group 4: 1
- Classroom management/authority — Group 1: 1; Group 3: 2; Group 4: 3
- First-year teaching reality — Group 3: 6
- Youth and credibility — Group 1: 1; Group 3: 2; Group 4: 1
- Emotional challenges — Group 3: 3; Group 4: 1
- Students not caring / fear of the field — Group 3: 2; Group 4: 2
- Systemic or bureaucratic concerns — Group 3: 2; Group 4: 1
- Getting hired — Group 4: 2
- Family responsibilities — Group 4: 2
- Other (finances, disability, taking criticism) — sparse mentions across groups

Counts reflect coded mentions within groups and show relative emphasis across groups. Additionally, as responses were analyzed by researcher, ‘stayers’ appeared to exhibit more depth of thought in their answers as compared to ‘leavers.’ The groups still teaching had answers that appeared more nuanced.

Reasons Why Teachers Left

Beyond coded data, the authors leveraged their long-term mentoring relationships and personal knowledge of participants to provide additional narrative insights into departure reasons. Of the nine participants who left teaching during the study period, reasons included family commitments (two cases), mental health concerns (two cases), negative student teaching experience (one case), transition to college-level instruction (one case), a more lucrative job opportunity (one case), generally feeling overwhelmed (one case), and leaving due to dissatisfaction with school bureaucracy (one case).

These narratives highlight the heterogeneity of pathways out of public-school teaching and underscore that attritional decisions often reflect life-course events and contextual constraints rather than the candidate's pre-admission academic profile. Combined, both coded and narrative data suggest that structural and situational factors (e.g., family formation, mental health, workplace conditions) often override gatekeeping metrics in shaping career trajectories.

Discussion

In research and academia, there is a tremendous premium on positive results – findings with high correlations and clear patterns. Negative results routinely go unpublished. But the STEM education community needs to seriously consider the possibility that success metrics and personality indicators *might not* effectively predict anything meaningful about teacher retention. By definition, failure to reject a null hypothesis is a weaker finding. Yet those entrusted with the allocation of *billions* in teacher preparation incentives and often with decisions about who receives support and who does not have a responsibility to critically examine who is favored within the systems they oversee. In the context of the scholarship and mentoring program examined in this study, there appeared to be little evidence that the indicators examined here were meaningfully connected with retention in the STEM classroom. Instead, we saw tremendous variety within each outcome group – from differences in SAT scores, to differences in teachability and resilience.

Analyzing the graduates as a group, 21 of the 44 students (48 percent) were teaching beyond their minimum teaching requirements in a public-school STEM classroom while 15 of the students (34 percent) are still teaching but had not yet met their minimum requirements. This means that 36 of the 44 total students (82 percent) were still teaching following the completion of the STEM certification program at SFA. Of the nine who were no longer teaching in a public-school setting, only four (9 percent) quit the teaching field before finishing their minimum required years of teaching. For context, Carver-Thomas and Darling-Hammond (2019) measured the national teacher attrition rate at about 8 percent annually, with average turnover rates for science and mathematics teachers being higher – from 18 percent in Title I schools to 11 percent in non-Title I schools. These statistics also do not account for the dramatic rise in teacher attrition due to Covid (Goldhaber & Theobald, 2022).

The study concluded that none of the numeric measures were predictive of either fulfilling a scholarship’s teaching commitment *or* persisting in a STEM classroom. Similarly, interview and essay protocols aimed at investigating applicants’ motivations for teaching, their teachability, and their experience working with students did not yield conclusively different results for ‘stayers’ and ‘leavers.’ Based on these analyses and the present data, within our program and based on these indicators, attempting to predict which pre-service teachers will later teach long-term and which are likely to leave the STEM teaching field early would be unfruitful. The clear majority of students – 82 percent – were still teaching, which could mean that overall, students who complete teaching programs with supplemental support like this project are likely to stay in the field of teaching long-term. These findings are consistent with previous research that indicates that teachers from traditional programs are more likely to stay in the teaching profession as compared to those who complete an accelerated certification program or similar alternatives to traditional programs (Coenen et al., 2018; Marder et al., 2020; Redding & Smith, 2016).

The only distinction that appears within our work revolves around how potential STEM teachers think about potential challenges and persisting through them. It appears that nearly all individuals perceive challenges, but that those who persist may think about a greater variety of challenges and consider them in greater depth. However, this would be a challenging characteristic upon which to select certain STEM teacher candidates over others.

Based on our findings, we were challenged to question whether filtering to select "better" students might be an ineffective way of attempting to select teacher candidates, even though these are often set as requirements by state or federal organizations who provide funding opportunities for such programs. These state or federal restrictions on scholarship programs (or possibly even educator preparation programs in general) could potentially limit the size of the talent pool for STEM educators without meaningfully identifying candidates who are more likely to persist in the field. This aligns with existing findings that GPA, standardized tests, and other academic criteria, have not shown that these criteria predict students becoming more "qualified" teachers (Basom et al., 1994; Byrnes et al., 2003; Shechtman & Godfried, 1993).

Limitations

Several limitations exist in this study. First, data from only one teaching program was used. As such, these numbers and findings will differ across programs, universities, or states. Further, our sample included only 44 students, and each group differed in terms of size. Additionally, while previous research indicates that resilience is an important factor needed to ensure teachers stay in their field and do not leave early (Arnup & Bowles, 2016; Hong, 2012), our study failed to show this to be the case for 'stated resilience' in open ended questions. This could be because we did not use an instrument specifically designed to test resilience. Last, by design survey participants had been already vetted for ability or potential to graduate college. This allows for examination of students *with supports but* does not directly address the questions of whether students who were not selected for support would have persisted if they had received that support.

Conclusion

The study contributes to ongoing debates about how best to recruit and select STEM teachers. By showing little predictive value in conventional gatekeeping metrics, the findings encourage policymakers and program designers to consider broader, support-focused strategies to address STEM teacher shortages. Within the T4 scholarship program, traditional metrics and applicant dispositions as captured in essays and interviews were not useful predictors of long-term classroom persistence. Instead, reflective anticipation of practical and emotional challenges, and access to sustained mentoring emerged as more promising avenues for supporting retention. Scholarship and recruitment efforts should prioritize supports that help early-career teachers develop coping strategies and professional identity over academic filtering to identify talent.

Disclaimers

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Reframing Teacher Leadership: Contemporary Insights
by
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Abstract
Teacher leadership continues to be a highly discussed and researched topic in teacher education. Its multiple facets and relevance evolve with socio-political trends, the students' needs, models of teacher preparation, and more. Recent conversations in the literature turn to the importance of practice-based, equity-centered, and teacher-preparation-integrated models of teacher leadership. This article explores how the field of teacher education is relevant to public education in a seemingly evolving area where teacher leaders' characteristics continue to grow. Additionally, the article explores how teacher leadership interacts with and supports culturally responsive pedagogy, sustainable school reform, and professional development-oriented approaches.

Teacher leadership remains a central focus in educational research. This is reflected in its increasing importance in shaping instructional practices, equity initiatives, and systemic reform. Teacher leadership is multidimensional, encompassing mentoring, curriculum innovation, policy engagement, and culturally responsive pedagogy (Cumings et al., 2024; Schott & Muijs, 2024; Wang et al., 2024). Recent literature highlights the evolving nature of teacher leadership, integrating it into preparation programs and advancing both professional development and student learning (Smith & Patel, 2023; York-Barr & Duke, 2004). Stakeholders in education, hence, are encouraged to look at teacher leadership not merely as a set of responsibilities but as a dynamic practice that adapts to socio-political contexts, disciplinary demands, and the challenges of digital transformation.

Further exploration of recent literature emphasizes the intersection of teacher leadership with broader frameworks, including distributed and transformational leadership, culturally responsive practices, and sustainability education. These perspectives reveal how leadership functions as both a collaborative and identity-affirming endeavor, supporting teacher retention, fostering inclusive school cultures, and preparing educators to navigate emerging trends such as artificial intelligence and foresight planning (Bristol & Goings, 2025; Lee & Ng, 2024; Rivera & Tanaka, 2022; OECD, 2021; Spillane & Coldren, 2021). By exploring these diverse strands of research, this article presents contemporary understandings of teacher leadership and its implications for education, professional development, and student outcomes. In doing so, it positions teacher leadership as a critical lever for educational equity and innovation in an increasingly complex global landscape.

Teacher Leadership: Conceptual Expansion

Teacher leadership, as an essential component of instructional improvement and systemic reform, can inspire more educators at all professional levels by modeling innovation, cultivating trust, and advancing equity-oriented practices (Bellibas et al., 2025; Kausar et al., 2025). However, the nature of a teacher leader is ever evolving. Recent foundational research has expanded its definition, investigated its functions, and outlined the conditions necessary for its effective advance. A comprehensive meta-analysis by Schott and Muijs (2024) reveals that teacher leadership encompasses various roles such as instructional expertise, peer mentoring, curriculum design, and policy engagement. This broadened perspective highlights that leadership is both formal and informal, existing across different roles and contexts. Similarly, Harris et al. (2025) argue that teacher leadership must be understood as a dynamic process embedded in school systems, where alignment between organizational structures and teacher agency is critical for sustainable change.

Additionally, an organic system to foster teacher leadership appears beneficial for advancing it. The distributed and transformational dimensions of teacher leadership are practical leadership models. Distributed leadership models highlight collective agency where leadership is enacted through networks of practice rather than concentrated in a single role (Marks, 2023; Zhang et al., 2025). Reportedly, distributed and transformational teacher leadership enhances teacher satisfaction, retention, and innovativeness by promoting autonomy and collaboration (Lin, 2022)

Sustainable organizational school improvement requires capacity-building among teachers, positioning them as co-constructors of reform rather than passive implementers (Bellibas et al., 2025; Kausar et al., 2025). This shift aligns with global trends in professional development, where mentoring, collaborative inquiry, and curriculum co-design serve as vehicles for empowerment and innovation (Aypay, 2025). In this sense, teacher leadership is both a driver of instructional quality and a mechanism for advancing educational equity.

Culturally Responsive Teacher Leadership

Teacher leadership exerts a pivotal role in Culturally Responsive Education. Culturally responsive leadership (CRL) is a crucial factor in creating inclusive and equitable school environments. Cumings et al. (2024) analyzed CRL's pivotal role in shaping school cultures that recognize and celebrate students' diverse cultural assets. CRL is an approach that not only acknowledges students’ varied cultural backgrounds but also actively challenges deficit narratives that portray these backgrounds as barriers to success. By advocating for systemic change, CRL promotes an educational landscape where all students feel valued and supported. This commitment to equity intersects with questions of teacher identity and retention, particularly among educators from historically marginalized groups, suggesting that culturally responsive practices must extend beyond students to include the educators who serve them.

In conjunction with CRL, the concept of identity and retention emerges as an essential theme in education. Bristol and Goings (2025) examine the motivations of black male educators and find that leadership opportunities that affirm identity and focus on community impact significantly enhance retention among these educators. Their findings suggest that when teachers are placed in leadership roles that resonate with their cultural identities and connect them with the broader community, they are more likely to remain in their positions. This linkage between culturally affirming leadership and educator retention highlights how CRL principles can be operationalized through identity-centered pathways, ensuring that equity is sustained not only in student experiences but also in teachers' professional lives.

Furthermore, the framework of social justice is integral to understanding effective leadership practices within urban schools. Shields and Hesbol (2020) investigated transformative leadership practices in these settings, emphasizing the importance of ethical decision-making, inclusive pedagogy, and advocacy for marginalized communities. Teacher leaders often navigate complex systemic barriers, yet they play a crucial role in promoting equitable practices within their schools. Viewed alongside CRL and identity-affirming retention strategies, social justice leadership provides the ethical grounding that ensures these practices are not isolated initiatives but part of a coherent, systemic effort to dismantle inequities.

Distributed Leadership

The model of distributed leadership also emerges in the literature as a central theme in the enactment of teacher leadership. Distributed leadership is characterized by shared responsibility and collaborative decision-making, where leadership roles are enacted through established routines and interpersonal relationships (Spillane & Coldren, 2021). Unlike hierarchical models that centralize authority in a single leader, distributed leadership recognizes the informal and formal influences that shape organizational processes. In schools where this model thrives, teachers participate in instructional teams, peer mentoring, and collaborative curriculum design, resulting in greater satisfaction and improved retention rates. Marks (2023) underscores this point by showing that distributed structures not only improve retention but also foster a sense of belonging, which is critical for sustaining teacher morale and reducing attrition.

Distributed leadership is a key element in advancing teacher leadership. Woo et al. (2022) argue that promoting teacher leadership practices within distributed frameworks ensures consistency and sustainability across schools. Their research highlights how administrative support and clear structures enable teachers to assume leadership roles beyond the classroom, thereby strengthening collective efficacy. This model is particularly important for ensuring that leadership opportunities are not incidental but embedded in schools' organizational fabric. Similarly, Lin (2022) demonstrates that distributed leadership significantly enhances teacher innovativeness, particularly when mediated by autonomy and professional collaboration. Lin’s study reveals that when teachers are empowered to exercise professional judgment and collaborate meaningfully with peers, they are more likely to engage in innovative practices that improve instructional quality.

Distributed leadership presents a transformative shift in educational leadership, positioning teachers not only as implementers of policy but as co-architects of school culture and success. Marks (2023) emphasizes that distributed leadership structures contribute to teachers’ sense of belonging and recognition, which directly influences their decision to remain in the profession. In the same spirit, Nguyen et al. (2024) provide evidence that leadership practices promoting teacher autonomy, professional development, and voice are critical to retention. Their comprehensive review argues that when teachers perceive themselves as active agents in school decision-making, they are more likely to remain committed to their institutions in the long term. Woo et al. (2022) further reinforce this by showing that when distributed leadership is formalized through policy and practice, schools are better positioned to sustain teacher leadership initiatives over time, thereby reducing turnover and enhancing collective efficacy.

Transformational Leadership

Complementing the principles of distributed leadership, transformational leadership emphasizes vision-setting, role modeling, and capacity-building as central mechanisms for fostering professional growth (Lee & Ng, 2024). Transformational leaders inspire their teams to transcend traditional boundaries, encouraging innovation, reflective practice, and collective responsibility. The connection between transformational practices and educators’ psychological well-being is particularly noteworthy. Bellibas et al. (2025) suggest that leadership structures grounded in both distributed and transformational frameworks enhance teachers’ emotional resilience. As educators navigate the complexities of their roles, supportive leadership approaches can mitigate stress and increase job satisfaction. By promoting practices that value teacher input and foster a sense of belonging, schools can create more positive, sustainable work environments. Recent scholarship further highlights the relationship between transformational leadership and teacher empowerment. De Jesus (2025) suggests that principals who consistently practice transformational leadership—through inspirational motivation, individualized consideration, and intellectual stimulation—significantly strengthen teachers' self-efficacy. By linking leadership practices to teacher agency, schools can foster environments where educators feel empowered to drive innovation and sustain long-term professional growth.

Curriculum Innovation and Mentoring

The multifaceted ways in which teacher leadership is enacted include a range of educational and professional elements, each reinforcing the others. For instance, mentoring builds confidence, curriculum innovation fosters ownership, digital pedagogy equips teachers with future-ready skills, and PLCs sustain collective growth. Hence, positioning teachers as leaders of pedagogical improvement and systemic change.

Mentoring

Mentoring is a powerful tool for professional growth, particularly for novice teachers seeking to develop their leadership capacities and reflective practices. Wang and Lee (2024) found that structured mentorship not only enhances novice teachers' reflective capacity but also encourages them to assume leadership roles within their schools. Effective mentoring relationships provide support, knowledge exchange, and a safe space for questioning and exploration, essential elements for building confidence and competence in teaching. Furthermore, York-Barr and Duke (2004) noted that instructional coaching serves as a critical leadership function, linking the mentorship process to improved pedagogical practices and student outcomes. Just as mentoring equips teachers with the confidence to lead, curriculum innovation demonstrates how teacher leadership extends beyond interpersonal support into the design of learning experiences that shape entire classrooms and schools.

Curriculum Innovation

Relevance and responsiveness in curriculum design are crucial in contemporary education, particularly within STEM (Science, Technology, Engineering, and Mathematics) fields. Smith and Patel (2023) underscored how teacher leadership can facilitate innovative approaches that meet the needs of diverse learners. An example of this is when a teacher leader collaborates with colleagues to develop interdisciplinary units that integrate scientific principles, civic engagement, and local data. These initiatives empower teachers to take ownership of their instructional practices, ultimately enhancing student engagement and learning outcomes.

Digital Pedagogy

As educational environments increasingly incorporate digital tools and resources, understanding the role of digital pedagogy has become paramount. Maaranen et al. (2025) underscored the necessity for teacher educators to lead the charge in technology integration within their classrooms. This involves not only selecting appropriate digital tools but also adapting and evaluating them to align with pedagogical goals. For instance, a teacher who effectively integrates a digital platform for collaborative projects can foster student engagement while teaching critical 21st-century skills. Leadership in this context means staying informed about emerging technologies and supporting colleagues in navigating their effective implementation.

Microlearning

Microlearning offers an innovative approach to professional development, emphasizing short, focused learning segments. Tate (2025) highlighted how microlearning can be effectively utilized within Professional Learning Communities (PLCs), enabling educators to lead brief, targeted sessions that cultivate continuous learning. This model not only distributes expertise across the community but also encourages teachers to share best practices and to collaborate on problem-solving. For example, a PLC might organize a 20-minute session in which teachers share strategies for managing classroom behavior, allowing for immediate application in their respective contexts.

The collective findings on mentoring, curriculum innovation, digital pedagogy, and microlearning suggest significant implications for teacher preparation programs. To nurture future educators' leadership skills, these programs should include components that focus on mentoring, co-designing curricula, and inquiry-based professional development. By embedding leadership opportunities within these frameworks, teacher candidates can develop the necessary skills and mindsets to thrive in dynamic educational environments.

Emerging Opportunities in Educational Leadership

Policy frameworks, digital innovation, sustainability imperatives, and foresight strategies shape the landscape of educational leadership. These areas intersect to redefine how teacher leaders engage with their institutions, communities, and broader educational systems. The subsequent literature highlights the importance of structured leadership pathways while also emphasizing the need for adaptability in the face of technological and societal change.

Policy Frameworks and Teacher Voice

Clear roles and structured career ladders remain fundamental to sustainable leadership. Martinez and Chen (2025) argue that such frameworks provide stability for instructional improvement and professional growth, ensuring leadership opportunities are accessible and transparent. However, structure alone is not enough. The Organization for Economic Co-operation and Development (OECD, 2023) stresses that legitimacy in educational reform depends on teacher voice. When educators actively influence policies that govern their practice, they not only strengthen reform credibility but also advocate for changes that directly improve student outcomes. Therefore, policy frameworks and teacher participation work together: structure offers clarity, while voice ensures relevance and legitimacy.

AI and Digital Transformation

Technology integration adds a new dimension to leadership. Zhang and Morales (2025) describe artificial intelligence (AI) as a double-edged sword, offering both opportunities and ethical challenges. Issues such as data privacy, algorithmic bias, and digital equity require leaders to balance innovation with responsibility. Teacher leaders might conduct an audit of AI tools to identify potential biases and develop ethical guidelines for their use. This role demands technical understanding, as well as moral values, connecting digital transformation to broader questions of equity and trust. Notably, the focus on teacher voice in policy reform also applies here: just as teachers must shape policies, they must guide the ethical use of technology to ensure it benefits all learners fairly (Zhang & Morales, 2025).

Sustainability Education

Leadership opportunities also emerge in sustainability education. Rivera and Tanaka (2022) highlight teachers as environmental advocates who can integrate ecological literacy with community partnerships. Such initiatives go beyond curriculum design to include systems thinking, linking educational practices to environmental stewardship and civic engagement. Teacher leaders might collaborate with local organizations to create hands-on learning experiences that connect classroom lessons to real-world ecological issues. This form of leadership reflects the ethical aspect of AI adoption: both require leaders to consider long-term impacts and embed equity and responsibility into their work (Rivera & Tanaka, 2022).

Foresight and Innovation

Innovation is a key characteristic of effective leadership. The OECD (2021) introduces foresight tools like scenario planning and horizon scanning, which help teacher leaders envision multiple futures and prepare accordingly. By running foresight workshops, leaders can foster a culture of strategic innovation, equipping educators to handle unexpected challenges. This future-focused mindset brings together the previous areas: structured frameworks provide stability, teacher voice ensures legitimacy, AI calls for ethical mindfulness, and sustainability calls for systemic awareness. All of these come together in foresight practices that prepare leaders not just to respond to change but to shape it actively (OECD, 2021).

Conclusion

The contemporary reconceptualization of teacher leadership underscores its significance as a driver of instructional improvement, equity, and systemic reform. By situating leadership within both formal and informal roles, scholars highlight its multifaceted nature, encompassing mentoring, curriculum innovation, policy engagement, and reflective practice (Hilal et al., 2022; Schott & Muijs, 2024; Smith & Patel, 2023). Equally important, culturally responsive leadership challenges deficit narratives and affirms diverse identities, ensuring that leadership pathways resonate with educators’ lived experiences while fostering inclusive school cultures (Bristol & Goings, 2025; Cumings et al., 2024; Shields & Hesbol, 2020). Together, these perspectives position teacher leadership as a dynamic practice that adapts to disciplinary demands, socio-political contexts, and the evolving challenges of digital transformation.

Looking ahead, distributed and transformational leadership frameworks, alongside emerging trends such as AI integration, sustainability education, and foresight planning, provide critical pathways for preparing educators to thrive in complex environments (Lee & Ng, 2024; OECD, 2021; Rivera & Tanaka, 2022; Spillane & Coldren, 2021; Zhang & Morales, 2025). Preparation programs must therefore embed authentic opportunities for collaboration, vision-setting, and equity-centered practice, equipping teachers with the skills to lead inclusively and innovatively (Maaranen et al., 2025; Martinez & Chen, 2025; Tate, 2025). Ultimately, cultivating teacher leadership not only strengthens professional development and retention but also enhances student learning by fostering classrooms that are responsive, resilient, and future-oriented. In this way, teacher leadership emerges as a cornerstone of educational equity and innovation, shaping schools that are prepared to meet the demands of a rapidly changing world.

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