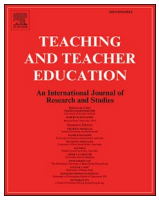
Teaching and Teacher Education 167 (2025) 105191

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate



Research paper

Examining science and mathematics teacher candidates' evolving perceptions and identities through a STEM early field experience with marginalized youth

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ARTICLE INFO

Keywords:
Early field experience
Teacher preparation
STEM education
Culturally relevant pedagogy
Inclusive education

ABSTRACT

A persistent challenge in teacher education is preparing candidates to engage equitably with marginalized youth in STEM classrooms. This study examines how an early field experience (EFE) shaped the perceptions of fifteen Noyce Scholars participating in a STEM summer enrichment program embedded in graduate coursework on equity and inclusion. Weekly reflective journals captured candidates' evolving understandings of teaching and learning. Analysis revealed non-linear growth in relationship-building, student engagement, and cultural responsiveness. Many shifted toward asset-based pedagogies and began recognizing systemic inequities. Findings underscore the value of EFEs that combine authentic student interaction, guided reflection, and coursework to foster inclusive teaching.

The demographic composition of teacher candidates in the U.S. contrasts sharply with the students they serve. Within many teacher preparation programs, most candidates are white, middle-class women, whereas K-12 student populations are increasingly diverse (National Council on Teacher Quality, 2024). This mismatch underscores the critical need to explicitly prepare teacher candidates to teach equitably by equipping them with the knowledge, skills, and dispositions to recognize systemic inequities, respond to the diverse needs of their students, and implement culturally responsive and inclusive instructional practices. Early field experiences (EFEs) are widely recognized as a key component of this preparation; however, there remains a significant gap in understanding the specific outcomes these experiences yield for teacher candidates (Dack & Ann Tomlinson, 2025; Kwok & Bartanen, 2022). This gap is particularly pronounced when examining how teacher candidates grow in their capacity to teach students who have experienced persistent marginalization (Caster, 2023; Kwok et al., 2025).

Persistently marginalized students, as defined in this study, include those from low-income households, students of color, multilingual learners, students with disabilities, LGBTQ + students, and those experiencing homelessness or housing instability (Health Equity Action Network, 2025). Addressing these systemic inequities is a critical objective for many teacher preparation programs, including the one featured in this study. These programs strive to cultivate EFEs that prepare teacher candidates to not only teach but also build authentic, affirming relationships with students from marginalized backgrounds (Kaur & Singh, 2023; Zeichner, 2022). These experiences in tandem with culturally relevant and inclusive coursework can support candidates to the reflect upon the complexities of educational inequities as well as their own identities, biases, and positionalities (Author, 2025; Darling-Hammond et al., 2022; Matias & Zembylas, 2014; Sleeter & Owuor, 2011; Wachira & Mburu, 2019).

Despite the recognized potential of early field experiences (EFEs), we lack sufficient understanding of how these experiences specifically influence science and mathematics teacher candidates' development of equity- and inclusion-oriented identities. This is particularly important as teacher preparation programs strive to equip candidates to respond to the needs of persistently marginalized students in STEM contexts.

Research questions

To address this gap, this study addresses the following research questions:

1) How do science and mathematics teacher candidates' perceptions of marginalized youth evolve during an early field experience in a STEM enrichment program?

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https://doi.org/10.1016/j.tate.2025.105191
Received 24 March 2025; Received in revised form 18 July 2025; Accepted 21 August 2025
Available online 9 September 2025

2) How do teacher candidates describe their developing identities as culturally responsive science and mathematics educators through written reflections during the early field experience?

Guided by sociocultural and critical perspectives, this study examines the early identity development of Noyce Scholars as equitable and inclusive educators.

1. Literature review

1.1. Culturally relevant and inclusive teacher preparation for science and mathematics teachers

Many teacher candidates enter preparation programs eager to serve under-resourced, high-need schools but arrive with little personal experience in those contexts. Consequently, they may unconsciously carry implicit biases about students from historically marginalized communities (Zeichner, 2022). Without intentional support, candidates often interpret student challenges through a deficit lens (Lee & Gube, 2024; McGraw et al., 2024; Mueller, 2021; Uysal & Fallas-Escobar, 2024). To counteract deficit views of marginalized youth, programs must embed culturally relevant and inclusive frameworks throughout coursework and fieldwork, coupled with structured opportunities for critical reflection that prompt candidates to examine their assumptions and the influences shaping their teaching (Harrison & Brown, 2025; Le et al., 2024). Yet we still lack robust research on how secondary science and mathematics candidates internalize and enact social justice principles as part of their emerging professional identities (Ginsberg et al., 2021).

In science and mathematics classrooms, exclusionary language and rigid norms can dismantle students' sense of belonging, especially for those from marginalized backgrounds (Marosi et al., 2025). Culturally relevant instruction addresses this gap by connecting STEM content to students lived experiences and by employing inclusive pedagogies that affirm diverse ways of knowing (Abdulrahim & Orosco, 2020; Gay, 2018; Kolovou, 2023; Lee & Herner-Patnode, 2024). Strong teacher–student relationships further support identity development and foster belonging (Osterman, 2023; Zhai et al., 2024), challenging stereotypes and positioning students as valued contributors to the learning community (Lee & Gube, 2024). Equity-driven preparation initiatives, such as culturally relevant and inclusive coursework (Author et al., 2025- in press; Hutchison & McAlister-Shields, 2020; Silunas et al., 2024), writing critical autobiographies (Nganga & Jamison, 2024), field experiences with diverse learners (Hu et al., 2021; VanDerHeide & Marciano, 2021), and cross-cultural exchanges (Siliunas et al., 2024) equip candidates with the tools needed to design justice-oriented science and math lessons (Valdez & Bianchini, 2023).

Early field experiences (EFEs) serve as a vital bridge between university theory and classroom practice. Occurring before formal student teaching, EFEs immerse candidates in real educational settings and spark the initial formation of their professional identities (Nielsen, 2022). For science and mathematics candidates, well-designed EFEs integrate structured observations, guided reflection, and model and scaffold inclusive teaching strategies (Stroupe, 2022). In non-formal environments, such as summer enrichment camps or after-school programs, candidates can experience enhanced flexibility and inquiry-rich contexts where they can implement culturally responsive methods and reflect upon outcomes (Haatainen et al., 2024). Through scaffolded teaching opportunities like co-leading activities, facilitating group work, and adapting materials, candidates practice inclusive instruction in a supportive setting, gradually building the confidence to lead full lessons (Demoiny, 2020; Gardesten & Herrlin, 2024; Goldhaber et al., 2023).

It is important to put forth that EFEs must be more than "exposure" to diversity. Without intentional structure, clear equity goals, reflective prompts, and strong mentorship, they risk reinforcing harmful stereotypes rather than challenging them (Lander, 2011). Instead, research shows that deeply engaging with students' strengths and community assets is essential for cultivating asset-based mindsets (Ghaemi & Boroushaki, 2025). When EFEs are thoughtfully crafted to spotlight systemic inequities, promote critical reflection, and center culturally relevant pedagogy, they become transformative sites where future secondary science and mathematics teachers begin to embody inclusive, justice-oriented practice early in their careers (Goldhaber et al., 2022; Kwok & Bartanen, 2022).

1.2. Theoretical framework: Identity development as a lens for teacher preparation

This study draws on discursive identity theory (Gee, 2000), situated within sociocultural and critical perspectives, to understand how teacher candidates negotiate their emerging professional identities in STEM contexts. Teacher identity is widely understood as a fluid, socially situated, and critically informed construct that both reflects and shapes how educators position themselves relative to students, disciplines, and the broader aims of schooling (Golzar, 2020; Lave & Wenger, 1991; Leigh, 2019; Pishghadam et al., 2022). In sociocultural theory, identity unfolds as a lived narrative, a story told and re-told through participation in classroom and community practices, mediated by cultural norms, institutional expectations, and social interactions (Avraamidou, 2019; Wenger, 1998). When aspiring teachers enter preparation programs, they bring with them powerful pre-existing narratives, born from their own schooling, personal values, and disciplinary training, that shape their initial sense of how they are "supposed to teach". Yet these narratives are neither fixed nor complete; they are continuously disrupted and renegotiated as candidates encounter new pedagogies, work with diverse student populations, and negotiate shifting institutional mandates (Neander Christensson, 2024; Zhai et al., 2024).

This dynamic process is especially salient in secondary science and mathematics education, where systemic inequities and entrenched, exclusionary discourses continue to marginalize many learners (Galanti & Holincheck, 2025; Weiss et al., 2025). As secondary math and science candidates engage with equity-oriented coursework, early field experiences (EFEs), and equitable teaching frameworks, they must reconcile their strong content knowledge with the imperative to adapt instruction in ways that affirm and empower historically marginalized students (Ibourk, 2021; McGraw et al., 2024; Rodríguez & Navarro-Camacho, 2023). EFEs, whether in urban schools or non-formal settings like STEAM camps, become landscapes for thus this identity work, confronting candidates with real-world teaching dynamics providing them with a space to test and refine their beliefs about students, curriculum, and their emerging role as STEM educators (Braaten, 2019; Gainsburg, 2012). However, when EFEs lack explicit structures for reflection and mentorship, candidates may simply replicate traditional power dynamics rather than challenge them (Kinser-Traut & Turner, 2020; Lander, 2011; Sandoval et al., 2020).

To illuminate how identity is performed and negotiated, this study draws on discursive identity theory (Gee, 2000). Discursive identity emphasizes that who we are as teachers is continuously (re)constructed through language, including how we speak, write, and are recognized by others. In secondary STEM preparation, candidates' written reflections offer a window into this process; they reveal whether candidates default to deficit-based narratives or shift toward asset-based perspectives as they engage with social justice principles (Eutsler & Curcio, 2019; Rodríguez et al., 2020). By analyzing reflection texts from early STEM-focused EFEs, we examine how discourse, and the power relations embedded within it, shapes candidates' sense of agency, their interpretations of student capabilities, and their commitment to equitable teaching. This critical discursive lens is complemented by praxis from Freire (1996), which insists that reflection and action be intertwined. Teacher candidates do not merely observe inequities; through guided reflection they learn to articulate and then act upon insights about

systemic injustice. Our framework thus integrates sociocultural interaction, reflective praxis, and an explicit focus on power and recognition to capture the multifaceted nature of identity development in secondary STEM contexts.

International studies reinforce the need for this contextually grounded, reflective approach. For example, Meyer et al. (2023) identified different professional orientations among German preservice teachers including those who primarily focused on subject matter expertise, those who emphasized instructional planning and teaching practices, and those who centered their role around fostering students' holistic development. Meyer et al. (2023) highlighted how identity development can differ based on disciplinary background and program structure. Likewise, Lee and Gube (2024) documented in Hong Kong how intercultural education workshops enable candidates to co-construct new teaching narratives, negotiating tensions between their own schooling experiences and the cultural backgrounds of their learners. These global insights affirm that, while the context may differ, teacher identity emerges through iterative cycles of participation, dialogue, and reflexive critique.

By centering both critical and sociocultural lenses, this study attends to a gap in the literature on secondary science and mathematics teacher identity, particularly in relation to how candidates perceive and teach marginalized students during their earliest field experiences. In doing so, the study is grounded in a comprehensive framework for understanding how future STEM educators come to see themselves as equity-minded practitioners, capable of fostering inclusive and socially just learning environments.

2. Context

Institutional and programmatic context. This study was conducted at a mid-sized liberal arts university in the mid-Atlantic region of the United States, known for its commitment to social-justice-oriented teacher preparation. The university's School of Education centers its programs on frameworks that prepare candidates to recognize and address systemic inequities within schools and society (Cochran-Smith, 2009). Candidates are prepared to make content relevant to students lived experiences, support academic achievement through differentiated instruction and individualized support, and foster students' critical consciousness; this preparation includes core tenets of culturally relevant pedagogy (Ladson-Billings, 1995).

A cornerstone of the graduate-level secondary teacher preparation program is its robust fieldwork model, which includes early, short-term, and long-term clinical experiences in partnership with a large, urban public school district located nearby. This district serves approximately 26,000 K-12 students, of whom 71% identify as Black or Hispanic and 58% are classified as economically disadvantaged. The longstanding partnership between the university and the district is mutually beneficial, university faculty support the preparation of new teachers while also contributing to the ongoing professional development of practicing teachers in the district.

Development and expansion of the STEM Enrichment Program. In 2022, university faculty and district leaders co-developed a two-week summer STEM enrichment program designed for approximately 100 middle school students, with a focus on engineering design. This program was intentionally structured to pair certified district teachers with secondary teacher candidates from the university, providing small-group, hands-on learning experiences. The curriculum and program design were collaboratively created, ensuring alignment with district initiatives and the university's focus on equitable STEM education.

The program quickly expanded, now serving students in grades 3 through 10 across four weeks, funded by a combination of local and national grants. Camps vary annually and reflect district priorities, university research, and partnerships with local business and community organizations. Each year, these "STEAM camps" offer unique, project-based learning experiences, such as designing model cities with robotics (for elementary students) or building and programming drones to navigate obstacle courses (for high school students). Over three years, nearly 1000 students have participated.

Admission to the summer program is open to all middle and high school students in the district, with free transportation provided. However, participation is limited to the capacity of a central middle school, and selection is determined by a lottery system. Unlike traditional summer school focused on remediation, this enrichment program aims to foster STEM identity and interest among students from historically marginalized backgrounds.

Integration with graduate teacher preparation. A distinctive feature of this initiative is the alignment of the summer STEM enrichment program with the initial coursework for graduate secondary teacher candidates. The 15 participants in this study are Noyce Scholars, science and mathematics majors selected for academic merit and their commitment to teach in high-need schools, who were beginning their experience in a 14-month teacher preparation program centered on equity and inclusion. The summer program takes place at an urban middle school serving predominantly African American youth in grades 3–10 and is scheduled concurrently with two foundational courses: *Teacher Inquiry for Equity and Inclusion* (focused on research-based practices for equity, inclusion, and student engagement) and *Teachers, Schools, and Community* (exploring the social, cultural, and policy contexts that shape K–12 education). This intentional alignment ensures that teacher candidates' fieldwork is deeply integrated with their coursework.

As a component of their first graduate courses, the Noyce Scholars participated in the STEM summer enrichment program as an early field experience (EFE). During this program, teacher educators, including the author, introduced strategies that culturally affirm and include students. These strategies guided candidates' initial collaborations with certified teachers, supported relationship-building with students, and scaffolded their ability to adapt curriculum for engagement and provide positive academic and social feedback (Council for Exceptional Children, 2017; Ladson-Billings, 1995).

Teacher candidates engaged in daily cycles of preparation, teaching, and reflection. Each day began and ended with meetings led by university faculty, where candidates participated in readings, mini-lectures, and collaborative planning. Throughout the summer experience, candidates:

- Conducted interviews with their mentor teachers regarding teaching philosophy and classroom practices;
- Facilitated weekly focus groups with participating students to gather feedback on what they learned, what they enjoyed, and suggestions for improving the program;
- Practiced relationship-building techniques, such as the 2 × 10 strategy (i.e., spending 2 min each day for ten consecutive days engaging in a non-academic conversation with a student; Murphy, 2018);
- Submitted open-ended weekly reflections detailing their participation, significant moments, and personal insights.

This carefully scaffolded clinical experience provided early and sustained opportunities for teacher candidates to practice, reflect on, and refine equitable and culturally responsive instructional approaches. The structure of the partnership and the program ensured that candidates were not only exposed to theory in coursework but also given authentic, supported opportunities to enact these practices in real-world settings.

3. Methods

3.1. Participants

The participants in this study are 15 Noyce Scholars, science (10) and

mathematics (5) teacher candidates who were selected for the NSF Robert Noyce Scholarship over the past three years and who participated in this early field experience. These Scholars receive tuition support and opportunities that prepare them to work in high-need school contexts. All scholars were admitted into the program following essays and interviews that described their commitment to equity and inclusivity as well as their desire to serve persistently marginalized youth. Six scholars participated in Year 1, three in Year 2, and five in Year 3. Eleven scholars identified as female and 4 as male. At the time of the study, the median age of Scholars was 22, with only one math Scholar being a career switcher at 39 years old. Of the 15 Scholars, 10 are White, 3 are African American, two identify as Asian and White.

3.2. Data collection and analysis

The qualitative analysis of Noyce Scholars' reflections employed a thematic analysis approach (Braun & Clarke, 2006) to systematically identify patterns in how scholars conceptualized and operationalized socially just and inclusive teaching. The analysis followed an iterative process of data organization, coding, theme development, and interpretation to ensure a rigorous and comprehensive understanding of their experiences in culturally diverse STEM classrooms.

Noyce Scholars completed structured reflective journals throughout their early field experience in the summer STEM enrichment program. Reflection prompts were developed by the author and colleagues with experience in preservice teacher preparation and grounded in prior cycles of program implementation. Prompts encouraged scholars to narrate daily events, describe classroom interactions, and reflect on moments that challenged or affirmed their assumptions about teaching and learning. Each reflection entry typically included:

- *A brief narrative of what happened in the classroom that day or during a particular lesson or activity (*e.g.*, "What happened today?")*
- *What stood out for you? (*e.g.*, key moments, surprises, challenges, or student reactions)*
- *What questions are still lingering for you? (*e.g.*, dilemmas, uncertainties, or next steps in their development as teachers)*

Scholars' responses were often narrative in nature, capturing both concrete classroom events and evolving perceptions of their roles as emerging teachers. Reflections frequently addressed issues such as: group dynamics, strategies for student engagement, curricular adaptations, navigating uncertainty, building relationships with students and mentors, and personal growth as educators. A reflection rubric was provided to guide students in producing in-depth, critically engaged responses that moved beyond description to include analysis of their decision-making, adaptations, and the impact of their actions. While the reflection instrument was not formally validated, it was informed by the author's prior experience with reflective practice, feedback from colleagues, and ongoing cycles of faculty review and adaptation based on student feedback. Regular faculty check-ins supported the clarity and relevance of prompts, resulting in minor revisions over time.

Reflections were first chronologically organized for each Noyce Scholar, grouping reflections by cohort year. Each scholar's reflections were structured from their initial field experience entry to their final reflection, resulting in over 100 pages of double-spaced text from secondary science and mathematics teacher candidates. The author and a graduate assistant independently reviewed the reflections multiple times, making preliminary analytical notes on scholars' discussions of socially just and inclusive teaching (Creswell, 2007).

A line-by-line coding process was employed to generate initial descriptive codes that captured discrete ideas, actions, and sentiments related to equity-focused teaching (Saldaña, 2021). Descriptive codes included, "building relationships and trust", "adapting content and pedagogy to promote student engagement", "addressing student diversity and identity in the classroom", and "recognizing implicit biases and structural inequities." To ensure consistency in coding, the author and graduate assistant independently coded a subset of reflections, compared excerpts, refined code definitions, and discussed discrepancies until consensus was reached.

The initial codes were then grouped into broader themes that captured scholars' evolving perspectives on teaching for equity and inclusion. Thematic clustering included: Student Engagement and Adaptability (e.g., using inquiry-based instruction, modifying lesson plans based on student needs), Building Meaningful Teacher-Student Relationships (e.g., fostering trust, developing rapport, understanding student backgrounds and experiences), and Developing Cultural Awareness and Responsiveness (e.g., valuing student identities, adapting teaching strategies for diverse learners). Themes were reviewed and refined to ensure they were internally coherent, distinct from one another, and well-supported by the data (Braun & Clarke, 2006). To illustrate the themes, direct excerpts from reflections were incorporated into the analysis, showcasing how scholars interpreted student engagement, interactions with students, and students' experiences in the camp. All the names of Noyce Scholars are pseudonyms.

4. Findings

The reflections of Noyce Scholars during their EFE reveal a developmental continuum in their understanding of culturally relevant and inclusive education. Scholars entered the program with varying levels of experience working with students, particularly those who have been persistently marginalized in STEM. Over time, their professional identities evolved, and their orientations toward equity and inclusiveness shifted as they engaged with new experiences and insights. Three key themes emerged from their reflections: student engagement and adaptability, building meaningful teacher-student relationships, and developing cultural awareness and responsiveness. These themes represent distinct yet interconnected continua, illustrating the ways in which Scholars navigated the complexities of culturally relevant and inclusive practices. Each scholar's starting point differed, and their professional identity developed in unique ways. While some made significant strides toward transformative, action-oriented teaching practices, others remained at earlier stages, reflecting a more clinical approach. Ultimately, this continuum highlights the diverse developmental trajectories of Noyce Scholars and underscores the importance of tailored support from teacher educators to meet their evolving needs in fostering equitable and inclusive teaching practices. Below, we examine each theme in greater depth.

4.1. Student engagement and adaptability

The theme of student engagement emerged prominently in the reflections of Noyce Scholars. Scholars explored strategies for promoting active learning and assessing whether students were truly engaged. While all Scholars considered engagement an essential component of effective teaching, their reflections demonstrated a range of interpretations and responses, from broad observations to specific insights and actionable strategies. Those in earlier stages primarily described engagement through observable behaviors, such as whether students "liked" activities or appeared interested. For example, in Jose's first reflection, he wrote, "A good number of the students were very attentive and excited about the events of the day." Their reflections often included passive observations, such as identifying disengagement without taking steps to address it. Early reflections often framed engagement in superficial terms, focusing on whether students enjoyed or disliked activities. Several Scholars noted that some students "didn't want to be [in the program] to begin with", emphasizing disengagement without exploring ways to counteract it.

Others considered engagement at the whole-class level, such as Science Scholar Ben, who observed, "Something that stood out for me today was that the students appeared much more engaged, compared to

yesterday … The students had more fun when they were able to start designing and building their pilot models for the sea-level rise activity." Similarly, Ethan identified a disconnect between the curriculum and students' levels of engagement, explaining, "I am not sure how responsive the students were to the [socio-emotional] curriculum. These activities focus on big picture topics and long-term goals, and these rising freshmen were struggling to conceptualize these ideas." Serena echoed this concern, critiquing a presentation for third graders: "A lot of the content … was made by people unfamiliar with the engagement patterns of third graders … [The students] looked like they were falling asleep watching [a 15-min nature documentary]."

As Scholars gained experience, some began identifying concrete ways to improve engagement by refining lesson design and increasing rigor. For instance, mathematics Scholar Joyce suggested incorporating Python programming for sixth graders, believing they were ready for more advanced challenges. Science Scholar Olivia advocated for a more constructivist approach, reflecting, "It could have been helpful for the students to just get in there and start playing with the materials … instead of spending so much time conceptually planning." Other Scholars posed thoughtful questions and made targeted recommendations. Scarlett considered ways to better foster student relationships, while Anjali critiqued curriculum pacing and structure, explaining, "I believe the reason students sped through the assignment or spent a large amount of time off-task was because it was not engaging to them."

A few Scholars moved beyond reflection and actively modified lessons to enhance engagement in real-time. Eunice collaborated with her mentor teacher to incorporate emotionally resonant activities, such as having students write a storyboard for their robotic pets. Sasha introduced choice into the curriculum, noting, "We made a few alterations to the curriculum, mostly providing the students with the choice to complete it all as group discussion work opposed to individual reflection only." Joyce, recognizing her students' prior knowledge, adapted her instruction accordingly: "I knew that a lot of the class had already block-coded before, so instead of explaining everything, I taught the students which block they needed to start, gave them 2 min to play around with it, and then had the students explain everything they were able to do." Scholars further along the continuum took a more proactive approach, modifying lessons in real-time to better align with students' interests or making accommodations for students with disabilities to increase accessibility. These adjustments reflected a growing understanding of engagement as something that teachers can intentionally cultivate rather than a static characteristic of students.

4.2. Building meaningful teacher-student relationships

The theme of building relationships was featured prominently as teacher candidates reflected on developing rapport and connection with their students. Scholars' reflections demonstrated growth along a continuum, from initially understanding relationships as broadly defined class dynamics to more personalized, nuanced connections. Initially, reflections were general and focused on creating a positive classroom atmosphere. Teacher candidates frequently associated positive relationships with having a welcoming, approachable demeanor, emphasizing their efforts to foster positivity and offer praise. Early reflections often illustrated relationship-building in broad terms or from the candidate's perspective rather than that of students. For instance, Ben noted, "I believe I am beginning to establish trust with my students, which will help me as we progress with the camp and engineering activities". He continues reflecting, "I am building connections with my class, and I believe they are more willing to share information with me regarding their personal and academic lives, which I fully intend to cherish and consider when offering them support in the future."

Some candidates began moving beyond broad statements to explore students' interests and backgrounds. Mathematics Scholar Adam described efforts to connect students' interests to tangible projects, noting, "I was also able to talk to a few students about their interests and attempted to give them guidance in forming these passions into an achievable project." He recalls one specific student who he enjoyed speaking with and wrote in his reflection, "One student was very interested in psychology and how individuals perceive stimulations different from each other. I am unsure how to best relate this topic to a project, but it was fascinating to hear Jacob talk about this subject." At this midpoint on the continuum, reflections indicated a shift toward recognizing students as individuals with distinct needs and interests. Scholars were also learning how to build positive relationships with students through the actions of the teachers that they worked with. For example, Olivia appreciated the co-teacher's willingness to deviate from the schedule to organize an impromptu birthday celebration for a student who had yet to arrive, involving the other students in signing a card and singing "Happy Birthday" when he joined the class. This small but meaningful gesture highlighted the value of personal connections in the classroom.

As Scholars deepened their experiences, they progressed toward personalized relationship-building, demonstrating nuanced awareness of individual students' lives and circumstances. Several Scholars documented specific, detailed interactions that showed sensitivity to students' needs. Leland's reflection illustrated his ability to forge meaningful connections, noting, "I represented a side of authority that was much more in-tune with their interests than the other authority figure, and in turn they opened up, accepted, and began to respect me." Olivia also showed personalized understanding when she recounted, "There was a good conversation about college, scholarships, and advocating for yourself. Some students expressed they would need a miracle to go to college and that they thought there were only scholarships for math/science focused people but not arts. We encouraged the students to pursue their passions and reach out for advice and assistance in accessing resources, for example reaching out to a professor in a field you are interested in."

Taryn's reflections consistently demonstrated high levels of personalized awareness, responsiveness, and empathy. She highlighted specific student needs and described tailored approaches to address them. She detailed one interaction:

> One thing I wish that [the district] did for Camp EAGER was-be more open with students' needs (IEP, 504, behavioral plans) because it does make a difference in how we should interact with some students. For example, I have one student who is not disruptive but is always on his phone. When it is brought up, he is extremely respectful and puts it away for a little while, but it eventually comes back. Some may find that he is disrespectful, but I thought [he may be on the] ADHD or Autism spectrum, so I approached him as such. He did tell me by the end of the day that he has autism and that he was thankful for my patience with him. I think [the EFE] has shown me that I can be flexible and innovative.

This continuum illustrates teacher candidates' growing complexity in understanding relationship-building, from a general classroom approach to appreciating and acting upon the uniqueness of individual students.

4.3. Developing cultural awareness and responsiveness

The third theme, cultural awareness and responsiveness, highlights the varied levels of awareness among Noyce Scholars regarding students' backgrounds and lived experiences. Their reflections indicate that while all Scholars evolved in their understanding, they remained at different points along a continuum. Some Scholars, like Jenessa (Science Scholar), initially viewed students' responses through a lens of disengagement, interpreting mentions of hobbies and after-camp activities such as "home" and "playing video games" as signs that students were "not very integrated into their communities" or spent excessive time "on their screens." Others, like Science Scholar Anjali, began with a more asset-based approach, emphasizing how students' relationships and

opportunities shaped their sense of belonging. She observed how familiarity with peers and trusted educators eased "first-day nerves," fostering stronger bonds and increasing "engagement and excitement for learning." She also recognized the role of school identity, where students interacted across school lines in ways that "promote open-mindedness." Beyond relationships, extracurricular interests such as basketball, dance, and robotics deepened students' ties to Newport News. Anjali highlighted a moment when her cooperating teacher connected a student interested in robotics with a team leader, reinforcing how experiences like these "can open up new opportunities for them to grow." Even students who expressed dissatisfaction with their schools still felt a connection to them. One student asserted, "If anything, it's my block," underscoring the complexity of place-based identity.

Other Scholars initially struggled to center students' experiences and cultural assets, often focusing on their own efforts to connect. Mathematics Scholar Adam, for example, described his approach, stating, "I was also able to talk to a few students about their interests and attempted to give them guidance in forming these passions into an achievable project." Jenessa similarly noted that interacting with middle schoolers felt intimidating at first, until she recognized their genuine need for supportive adults. Leland, on the other hand, attempted to use humor and pop culture references, but his reflections reveal both the challenges and moments of growth in his approach. "The hardest part of forging connections with most campers has to do with our cultural interests not aligning," he admitted, recalling how his references to "Def Leppard," "80s hair metal," and "SpongeBob Mermaid Man socks" were met with "silence." He also observed that students struggled to connect with a stricter teacher in the room, reinforcing the importance of relational approaches. Over time, Leland realized that cultural references were less important than simply showing up for students, reflecting, "I did not have time to think about being nervous to make connections with the kids. I quickly realized that they responded well to me when I simply checked on them."

Many Scholars directly or indirectly addressed the common stereotype that middle school students are an "unwanted" age group—often viewed as awkward or difficult to teach. While some Scholars reached a level of awareness where they actively challenged these assumptions, others took smaller steps in shifting their perspectives. Mathematics Scholar Eunice expressed a deep commitment to supporting middle schoolers, asserting, "I feel a strong vocation to work with this 'unwanted' age group. I want my middle schoolers to know that there is someone in their life who cares about them." Anjali took an advocacy role beyond the classroom by challenging her family's negative stereotypes of middle school students, sharing, "I sent my family a long text explaining how I feel and asking them to make fewer negative comments about children." Meanwhile, Serena recognized how students confided in her about difficult experiences, including negative encounters with past teachers and personal stories of grief and loss.

While some Scholars' reflections remained focused on interpersonal connections, others developed deeper awareness of socio-cultural and socio-political factors shaping students' experiences. Serena, for instance, noted how representation in a coding lesson influenced engagement. "A lot of the girls in particular spent a lot of time choosing characters who looked like them, and it really warmed my heart," she reflected. Drawing from her own experiences as an Asian female student, she shared, "Whenever I had the opportunity to choose a character or avatar as a young girl, I remember how exciting it was whenever I found one who really looked like me, but I also remember how rare that was for me." Her observations highlight how culturally responsive practices empower students by validating their identities.

Other Scholars demonstrated a growing ability to recognize systemic inequities. Taryn, an African American Scholar, reflected on the socioeconomic realities of students after they took a field trip to her university. She stated,

> I think my students had an enjoyable experience at [university]. I think it is important for me to state that there were students at [the summer enrichment program] who asked to take food from [dining hall] home so that they could feed their siblings. My thought following that response is that with the grant money we could supplement lunch with additional snacks every day, even if it is just a pack of cookies or a bag of chips. My heart tugged for those students because I know what that feeling is like. I just went home and cried after the field trip because I truly had no words. These kids go through more than most people realize, and coming from marginalized communities, having a FREE program like [the summer enrichment program] is just so incredible.

Her reflections illustrate a clear recognition of inequity and an advocacy for systemic changes, such as providing additional snacks to address food insecurity among students.

Taken together, these reflections reveal that Scholars were at different places in their ability to understand, connect with, and advocate for students' lived experiences. While all demonstrated growth, some remained focused on interpersonal rapport, while others moved toward deeper socio-cultural awareness and systemic advocacy. This range of perspectives underscores the complexity of becoming a culturally responsive educator, highlighting that while growth is possible for all, the journey is nonlinear and deeply personal.

5. Discussion

This study examined the reflections of Noyce Scholars through the lens of discursive identity theory, highlighting how Scholars negotiated and reconstructed their emerging professional identities during an early field experience (EFE). Consistent with discursive identity theory (Gee, 2000), findings demonstrated that Scholars' evolving conceptions of culturally relevant and inclusive teaching were articulated, challenged, and reshaped through their reflective narratives. Scholars' identity trajectories were notably diverse and nonlinear, echoing existing research emphasizing identity as fluid, contextually bound, and mediated through social interactions (Avraamidou, 2019; Lave & Wenger, 1991). The three key themes, student engagement and adaptability, building meaningful teacher-student relationships, and developing cultural awareness and responsiveness, illustrate distinct yet interconnected dimensions of this developmental process. These findings align with and extend existing literature on EFEs, culturally responsive teaching, and science and mathematics.

5.1. Navigating the complexities of student engagement

The findings suggest that Noyce Scholars entered the early field experience (EFE) with varied discursive identities regarding student engagement. Initially, many Scholars articulated engagement through superficial terms, reflecting traditional teaching identities centered on whether students appeared to enjoy or participate passively in activities. However, through structured reflection and interactions within culturally diverse classrooms, some Scholars began renegotiating their identities. They moved toward conceptualizing engagement as an active, responsive practice requiring culturally responsive adaptations of content and pedagogy to authentically meet students' cognitive and affective needs (Kwok & Bartanen, 2022; Stroupe, 2022).

Structured reflection emerged as critical in mediating Scholars' identity development from self-focused teachers toward student-centered educators. Initially, Scholars tended to discursively frame their teaching identity around their own performance, focusing primarily on delivering content effectively or managing behavior. This aligns with research indicating novice teachers initially adopt self-focused narratives of their teaching identity before moving toward a more student-responsive stance (Demoiny, 2020; Gardesten & Herrlin, 2024; Goldhaber et al., 2023). As Scholars spent extended time

reflecting and engaging directly with students, their identities evolved, demonstrating increased attention to student reactions, strengths, and needs. This shift highlights how intentional, reflective practice within EFEs can help candidates renegotiate their professional identities toward culturally responsive, student-centered teaching (Rodríguez et al., 2020). Scholars demonstrated the renegotiation of their identities by critically reflecting on students' interactions with content, assessing which instructional choices improved or hindered engagement, and determining how to responsively adapt their teaching in real-time. These findings also align with literature emphasizing that effective EFEs should scaffold opportunities for teacher candidates to not only practice teaching but also critically analyze student responses and refine their pedagogy accordingly (Goldhaber et al., 2023; Le et al., 2024). Without these structured reflections and extended exposure to students, teacher candidates risk maintaining a limited, teacher-centered identity, rather than recognizing their role in fostering a student-responsive learning environment.

Additionally, findings illustrate specific ways Scholars grappled with shaping their teaching identities within justice-oriented STEM contexts. For example, Joyce's recognition that students required more rigorous challenges in mathematics and Laura's advocacy for hands-on constructivist learning illustrate active identity reconstructions toward culturally inclusive STEM teaching. These examples show how some Scholars transitioned from passive implementers of prescribed curricula toward proactive, culturally responsive educators who actively drew on students' prior knowledge and cultural assets (Wachira & Mburu, 2019). However, not all Scholars achieved this level of discursive identity development, suggesting additional identity support through explicit coursework, mentoring, and prolonged clinical experiences is needed to fully bridge culturally responsive theory and practice (Kruse & Voss, 2024).

5.2. The role of relationships in teacher development

Scholars' reflections on teacher-student relationships revealed a developmental continuum, aligning with literature emphasizing the critical role of relationship-building in teacher preparation (Gay, 2018; Reddig & VanLone, 2024). Initially, many Scholars viewed relationships primarily through the lens of general classroom rapport, associating positive teacher-student interactions with establishing initial trust and a welcoming classroom climate. Research indicates that novice teachers often prioritize building rapport and personal connections with students early in their careers to create a conducive learning environment (Kaur & Singh, 2023; Osterman, 2023; Zeichner, 2022). As the Scholars gained experience, their reflections evolved toward more individualized and relationally responsive pedagogical approaches, consistent with relational pedagogies described by Gay (2018).

Importantly, this study contributes new insights by illustrating the uneven nature of relationship development, especially within the context of STEM education, fields traditionally characterized by content-driven teaching rather than relational engagement (Ginsberg et al., 2021). While some Scholars, such as Taryn, demonstrated nuanced responsiveness to students' unique socio-emotional needs and advocated explicitly for neurodivergent students, others, like Adam and Ben, remained primarily focused on general rapport without consistently translating relational insights into instructional decisions. This uneven trajectory illustrates the unique challenge science and mathematics educators face in balancing relational connections with rigorous academic engagement. Therefore, the findings highlight the complexity of fostering relational pedagogical practices within STEM contexts, emphasizing the need for differentiated support from teacher educators to bridge relational and instructional practices effectively.

5.3. Developing cultural awareness and responsiveness

The findings reveal significant variability in how Scholars engaged with students' cultural backgrounds and identities. Some, like Jenessa, initially viewed students through a deficit lens, attributing disengagement to personal shortcomings rather than structural or curricular factors. This finding is consistent with previous research indicating that teacher candidates often enter preparation programs with implicit biases that shape their interpretations of student behavior (Mueller, 2021; Zeichner, 2022). However, as Scholars progressed, some demonstrated growth toward asset-based perspectives, recognizing students' cultural and community connections as strengths. Anjali's reflections, for example, illustrate an awareness of how students form identities around school and place, reinforcing literature on place-based learning as a tool for equity-oriented STEM education (Valdez & Bianchini, 2023).

Notably, Scholars who exhibited a higher cultural awareness respective of their peers often had personal experiences that resonated with their students' backgrounds. Taryn, for instance, consistently reflected on the systemic barriers students faced, advocating for material supports such as additional snacks to address food insecurity. Her insights align with research on teacher identity development, which suggests that candidates with lived experiences of marginalization may be more attuned to equity issues in the classroom (Ramlackhan et al., 2022; Rivera Maulucci, 2013). However, even Scholars from backgrounds different from their students demonstrated the potential for growth when provided with structured opportunities for critical reflection and direct engagement with students (Le et al., 2024).

The findings extend this literature by illustrating how teacher candidates' written reflections serve as a window into their evolving discursive identities (Gee, 2000). Scholars' language choices, whether they framed students as disengaged or positioned them as active agents, offer insight into how they internalized or challenged dominant narratives about historically marginalized students in STEM. This underscores the need for teacher preparation programs to explicitly scaffold candidates' critical reflection on their own discourse, helping them recognize how their language shapes both their perceptions of students and their teaching decisions (Eutsler & Curcio, 2019; Freire, 1996; Rodríguez et al., 2020).

5.4. Limitations and future directions

While this study offers valuable insights, several limitations must be acknowledged. First, all participants were Noyce Scholars at a mid-sized liberal arts institution who had committed to teaching in high-need school districts before entering the teacher preparation program. As the project investigator, advisor, and instructor, it is important to acknowledge that all participants were selected for the scholarship based on demonstrated commitments to equity in science and mathematics education, as evidenced in their applications and interviews. This unique context may limit the generalizability of findings to teacher candidates without similar backgrounds. Future research should include preservice teachers from other institutions and non-Noyce contexts to explore how teacher identities develop across varied settings.

Second, the primary data source was participants' self-reported reflections, with no triangulation through classroom observations or student perspectives. Incorporating these additional data sources in future studies would strengthen claims about shifts in teaching practice and attitudes. Additionally, the early field experience (EFE) spanned only a few weeks in the summer. While participants showed promising growth, this study does not capture how identities evolve over time. Longitudinal research following participants into student teaching and the early years of their careers would offer deeper insights into the lasting impact of EFEs. It would also help determine whether those with modest initial shifts later catch up, or whether early trajectories persist. Third, while we documented *what* changes occurred in teacher candidate identities, we captured less about *why* some participants shifted more than others. Factors such as prior experiences, personal beliefs, and the quality of mentorship likely influenced outcomes, but were not systematically examined. Future work could explore these individual differences and

investigate how specific program elements, like mentoring styles or reflection prompts, affect development.

Finally, the study took place in a STEM summer enrichment camp, which differs from formal K–12 classrooms. Further research comparing informal and formal EFEs could illuminate how different contexts shape candidate growth and preparedness for equity-centered teaching. Despite these limitations, the study supports the strategic use of early field experiences to foster equity-minded teacher identities. Continued research and program refinement are essential to strengthening this promising approach.

6. Conclusion

The reflections of Noyce Scholars in this study highlight the value of early field experiences (EFEs) in shaping teacher candidates' understandings of equitable and inclusive education. Scholars demonstrated varying developmental trajectories, indicating that each preservice teacher begins and progresses differently along a continuum of student engagement, relationship-building, and cultural responsiveness. This variability underscores the necessity for teacher educators to carefully monitor and support preservice teachers' individual journeys, providing targeted, differentiated guidance to foster meaningful professional growth.

A key implication from this study is the importance of explicitly connecting EFEs to structured coursework, with consistent involvement from university instructors and veteran cooperating teachers. This integrated approach allows preservice teachers to practice culturally responsive and inclusive pedagogy within authentic classroom settings. Importantly, when preservice teachers receive intentional mentorship and continuous reflective opportunities, they not only better support their students but also experience reciprocal learning, as students unknowingly guide them to become more responsive, thoughtful educators.

However, the findings also caution that we must avoid viewing classrooms, especially those serving marginalized youth, merely as training grounds. Rather, EFEs should be spaces where preservice teachers, guided by experienced teacher educators, learn to authentically advocate for students. Ongoing dialogue through reflective practices, wherein teacher educators actively partner with preservice teachers, is essential to ensure ethical, equitable, and effective teaching practices. Future research should explore how structured, long-term mentorship and reflection throughout teacher preparation programs further enhance preservice teachers' capacity to become equitable and inclusive STEM educators.

Funding statement

The research reported in this article was supported by the National Science Foundation under Award No. 2342084. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

Declaration of AI use

During the preparation of this work the author(s) used ChatGPT to improve the clarity and conciseness of lengthy paragraphs. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Declaration of competing interest

I have nothing to declare.

Acknowledgement

The authors acknowledge the contributions of graduate assistant Stephanie Kent (skent@wm.edu), master's degree student in clinical mental health counseling with a concentration in military and veterans, for her assistance with data coding and literature review.

Data availability

Data will be made available on request.

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