Dagher, Z. R., & Metzger, C. (2024). Exploring preservice teachers' engagement in a digital clinical simulation for inclusive science education. *Contemporary Issues in Technology and Teacher Education, 24*(4), 521-549.

Exploring Preservice Teachers' Engagement in a Digital Clinical Simulation for Inclusive Science Education

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This study analyzed elementary preservice teachers' (PST) participation in an equity-oriented digital clinical simulation administered in a science methods course. Using the Teacher Moments' open access platform, PSTs completed the simulation, To Intervene or Not, about two students from historically minoritized communities who appeared disengaged during their fourth-grade science class. PSTs are put in the position of student teachers who are asked to identify causes for the classroom teacher's inaction, propose interventions, and reflect on their roles as teachers. A qualitative analysis of their responses showed that PSTs posed a range of productive questions, proposed a variety of viable interventions, and expressed an ethic of care, in which they saw themselves as responsible for the well-being and success of all students. Findings and implications for using equity-oriented simulations in teacher education are discussed.

Simulations are often used in professional settings such as military training, aviation training, medical schools, and teacher education programs to engage participants in challenging situations (Rooney & Nyström, 2018). They provide safe spaces for making decisions or engaging with actions that do not have immediate real-life consequences but serve to prepare participants to think and act like professionals when encountering new challenges. According to Lateef (2010), simulations can be used effectively in fields that require technical and functional training, developing problem-solving and decision-making skills, and enhancing interpersonal and communication skills.

In teacher education, simulations have been used to address a wide range of professional goals that range from supporting preservice teachers' (PSTs) ability to negotiate parental concerns (Dotger et al., 2009; Thompson et al., 2019) and practice the skills of eliciting and probing student knowledge through clinical role-playing (Thompson et al., 2022), to enhancing in-service teachers' equity-promoting behaviors (Littenberg-Tobias et al., 2021). Additionally, simulations have been used to support PSTs' ability to recognize inequitable student participation and motivate action (Self & Stengel, 2020). Simulations used in teacher education programs provide safe and scaffolded experiences that help develop PSTs' propensity to act equitably.

Equity-oriented interventions in teacher education programs are typically embedded in various programmatic configurations, curricular settings, pedagogical approaches, or teaching and learning activities (Liao et al., 2022). Most have been shown to lead to changes in the participants' dispositional qualities, which include "(1) raising awareness of inequity; (2) (re)examining assumptions about inequity; (3) positioning as agents of addressing inequity; (4) developing commitment to equity" (Liao et al., 2022, p. 7).

Studies that focus on teaching and learning activities use a variety of approaches that include equity audits and digital vignettes. Even though none of the interventions cited in a recent review were reported to have used simulations (Liao et al., 2022), the number of studies on the role of digital simulations in promoting equity and equitable mindsets in K-12 teacher and teacher education has been rising in recent years (Dutt et al., 2021; Sullivan et al., 2020).

This descriptive study contributes to the emerging literature on PSTs' participation in equity-oriented simulations. The simulation developed and used in this study was designed to activate PSTs' dispositions to act equitably in the context of teaching elementary science, thus addressing a critical aspect of science, technology, engineering, and mathematics (STEM) teacher education that has been understudied. The study's three research questions are aligned with the simulation's prompts:

1. What questions do PSTs raise when encountering students trapped in inequitable learning situations?

2. What interventions do PSTs propose to support students' equitable engagement in elementary science? and,

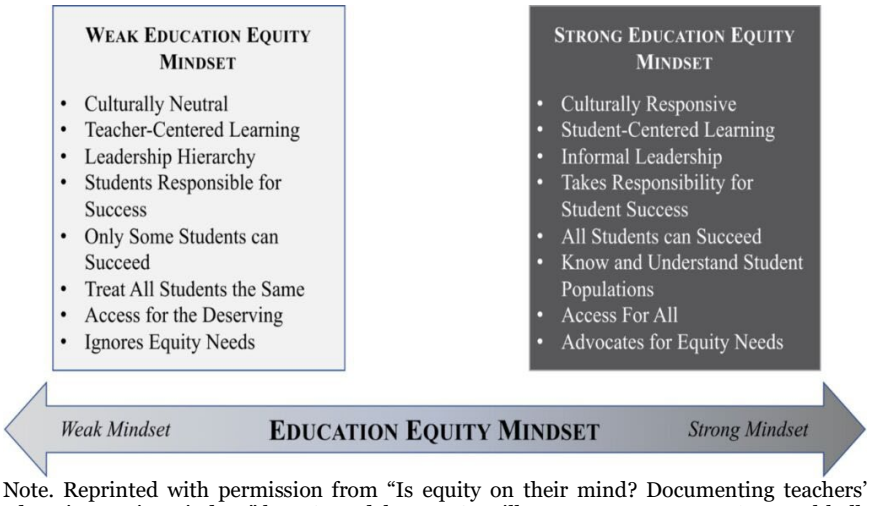
3. How do PSTs reflect on their role as teachers after participating in this simulation?

Evidence gathered from responses to these questions provides a window into PST's initial lines of reasoning when confronted with inequitable student participation in science class and the ways they view their roles and responsibilities under these circumstances.

Conceptual Framework

Promoting an equity-oriented mindset is an important goal for teacher preparation programs. An education equity mindset is defined "as a set of perceptions and motivations that lead to actions aligned with how individuals perceive equity situations in education." (Nadelson et al., 2022, p. 60). Nadelson et al. (2019) identified eight components of an education equity mindset that characterize teachers. These attributes include engaging in culturally responsive teaching practices, student-centered learning, informal leadership, taking responsibility for student success, holding the belief that all students can succeed, knowing and understanding student populations, working to provide access for all, and advocating for community needs. Furthermore, they conceived these attributes as occurring on a spectrum that ranges from weak to strong (see Figure 1).

Figure 1
The Education Equity Mindset Spectrum



Note. Reprinted with permission from "Is equity on their mind? Documenting teachers' education equity mindset," by L.S. Nadelson, R.G. Miller, H. Hu, N.M. Bang, & B. Walthall, 2019, *World Journal of Education, 9*, p. 27.

A complementary perspective that can further describe these characteristics in concrete terms is found in Rodriguez's (2015) proposed dimension of engagement, equity, and diversity intended to complement the three-dimensional performance expectations in the *Next Generation Science Standards* (NGSS Lead States, 2013). Components of this dimension are articulated in terms of specific actions that teachers can integrate into standards-aligned science teaching and assessment practices.

Examples of actions under engagement include attending to culturally relevant content and using various instructional strategies. Under equity, actions include ensuring that students with limited language proficiency have access to resources and providing accommodations for those facing resource limitations. Under diversity, actions include encouraging

students to tie cultural/ethnic backgrounds to investigations and ensuring that assessments are culturally sensitive and inclusive (see Rodriguez, 2015, p. 1023). Juxtaposing the frameworks of Nadelson et al. (2019) and Rodriquez allows the interpretation of ordinary teacher actions, or intended actions, along a set of variables that characterize an education equity mindset. Table 1 illustrates how specific teacher actions are situated within a broader conception of an education equity mindset.

Table 1
Select Attributes of an Education Equity Mindset and Corresponding Actions in the Dimension of Engagement, Equity, and Diversity

Education Equity Mindset (Nadelson et al., 2019)	**Dimension of Engagement, Equity, and Diversity (Rodriguez, 2015)**
Culturally responsive teaching. *Students' perspectives, cultures and experiences are recognized and respected in the learning environment.* (p. 27)	- Content is socially relevant (e.g., tied to everyday life and to students' concerns) (Engagement) - Content is culturally relevant (i.e., responsive to the classroom's cultural/ ethnic diversity and/or lack of it) (Diversity)
Student-centered learning *Students are often engaged in meaningful learning opportunities that draw upon students' personal experiences.* (p. 29)	- A variety of pedagogical strategies are used within every lesson focused on student-centered and collaborative learning (Engagement) - Students work in small groups (Engagement) - Differentiated instruction is provided (Equity) - A variety of grouping approaches are used (Equity) - Students are encouraged to tie cultural/ethnic backgrounds to investigations/activities/discussions (Diversity)
Knows and understands student populations and their needs. *Teachers understand student views and support their interests and needs* (p. 30)	- Students' family composition and variety of circumstances are seen as resources for building community and enhancing learning (Diversity)
Believes in access for all. *Teachers work to provide access to quality education* (p. 29)	- Each student has equal access to participate (Equity)

One way to improve teacher candidates' preparedness to confront educational inequities is to expose them to inequitable teaching situations in their teacher preparation program. These situations can be embedded in simulations within coursework to provide additional opportunities to approximate practice. Grossman et al. (2009) defined approximations of practice as "opportunities for novices to engage in practices that are more or less proximal to the practices of a profession" (p. 2058).

The capacity of simulations to approximate practice is one of the main reasons professional settings such as nursing, aviation, and teacher education use them. Approximating some elements of teaching practice allows teacher educators to support PSTs' development of desired dispositions and skills in a safe learning environment. One of the main

benefits of using interactive simulations is creating a level of discomfort that activates PSTs' sense of "pedagogical responsibility," which provokes the participating teacher to action (Self & Stengel, 2020, p. 59).

Two types of simulations are typically used to accomplish this goal: live actor clinical simulations and digital clinical simulations. The simulation interaction model (SIM; Dotger et al., 2010) and the SHIFT model (Self & Stengel, 2020) employ live actors who are trained to respond improvisationally to participants. Dotger has used SIM to develop school leaders' and teachers' knowledge and skills (Dotger, 2011; Dotger et al., 2009). Digital clinical simulations are patterned after the live actor simulation model, whereby the scenario's author embeds what the actors might say into the simulation either in the form of text, video, or voice, to which the participant provides an audio response (Hilliare et al., 2022). Teacher Moments, for example, offers an open-access authoring and simulation environment, whereby teacher educators can author a scenario or assign one from the existing bank of over 600 simulations to their PSTs to complete. (For more details, see Hillaire et al., 2022; Thompson et al., 2019).

The scenarios follow a typical structure that begins with presenting the educational context, after which participants anticipate potential interactions, respond to critical situations, and reflect on their role as teachers. (e.g., Barlow et al., 2023; Sullivan et al., 2020). The standardization of digital clinical simulations allows the administration and systematic analysis of participant responses at scale.

This study builds on findings from the growing research on digital clinical simulations in teacher education by describing the range of PSTs' questions, proposed interventions, and reflections as they face clear instances of educational inequity. Additionally, this study is significant to science teacher educators keen on supporting PSTs' ability to enact equitable and inclusive science teaching strategies. Analyzing how PSTs interact with different decision points in the scenario provides a window into their thinking. It generates questions about how teacher educators can promote PSTs' development of strong equity mindsets using digital clinical simulations.

Methods

Study Context

This study took place in multiple sections of an undergraduate elementary science methods course over three semesters (spring 2021, fall 2021, and spring 2023) at a mid-Atlantic university in the United States. PSTs typically enroll in this required course in the 3rd year of the elementary teacher education program before beginning their student teaching. Equity is a central theme in the course. It is woven into the fabric of its ambitious science teaching readings, discussions, and assignments that emphasize the goal of helping "students of *all* backgrounds to deeply understand fundamental science ideas, participate in practices of science, solve authentic problems together, and learn how to continue learning on their own." (Windschitl et al., 2018, p. 3).

Supporting students' equitable engagement with science is further emphasized in target readings of equity case studies (NGSS Lead States, 2013) and culturally relevant pedagogy (Ladson-Billings, 2011; Rodriquez, 2015). In recent years, two equity-oriented digital clinical simulations were added as homework assignments to provide PSTs with opportunities for practice (Bell, 2019) using the Teacher Moments platform, hosted and supported by MIT's Teaching Systems Lab (see https://teachermoments.mit.edu/). This study analyzes PSTs' engagement with one of the simulations.

Simulation Purpose and Description

The scenario within the Teacher Moments simulation, To Intervene or Not, was inspired by anecdotal observations told in class casually, though infrequently, by PSTs during field debriefing sessions. While these anecdotes shocked the instructor and the PSTs, they led to productive discussions regarding the short- and long-term impact of the teacher's failure to act in the interest of the children, denying them access to and participation in science learning. As such, these anecdotes constituted realistic accounts that held a strong educative value, forming, by default, valuable critical incidents that awaken PSTs' pedagogical responsibility, prompting them to identify underlying issues and consider a range of restorative actions. Faced by such situations, we anticipated that PSTs would combine knowledge and resources they accumulated from their life experiences, coursework, and school-based field experience to figure out what to do, as they might act if they encounter similar situations.

The first author designed the simulation to address these goals using fictional names for the teacher and the students. Developing this scenario on the Teacher Moments platform offered some logistical advantages. One advantage of presenting these critical incidents within this medium is the ability for each PST to audio-record their responses, which allows their thoughts to flow naturally as the scenario unfolded. IBM's Watson, which is a built-in feature of this platform, automatically converts the participants' audio responses into text. After engaging with the scenario individually in their own time, a debriefing class session followed to discuss PSTs' differing views, including the relative effectiveness of their proposed interventions and their perceptions of their roles as teachers.

In the simulation To Intervene or Not, each PST takes on the role of a student teacher placed in Ms. Jones' fourth-grade science classroom. In this role, the PST notices two students not engaging with science class even though they seem to be doing well in other subjects and specials. From a simulation authoring perspective, this specific detail was intentionally included to set up the case as a *teaching,* not a *student,* issue.

Josh is African American, and Leah is Latina. When approached individually by the student teacher, Josh asks to be left alone, and Leah looks puzzled and ignores them. After asking for guidance, Ms. Jones tells the student teacher not to worry, as the students have issues. The PST is prompted to ask questions to learn more about the situation. Ms. Jones provides additional context. She tells the PST that Josh is being raised by his grandmother, has good academic potential, and has not been diagnosed with learning difficulties. She believes that he does not seem to

get enough sleep or support for his homework at home and that his grandmother did not attend the parent-teacher conference. Ms. Jones has tried to engage him in the past, but he seems disinterested. She concludes that giving Josh a "break" during class is okay because he has a challenging home environment. She tells the PST they are welcome to experiment with different ways to engage Josh.

A decision point follows where the PST must decide whether to intervene to support Josh's engagement in science. If they decide to intervene, they are prompted to propose three actions to help improve Josh's engagement. Once they do so, they are asked to justify their choices regarding why they believe these actions will improve Josh's engagement. If they decide not to intervene to support Josh, PSTs are prompted to justify their decision.

Following this scenario, Ms. Jones provides more context about Leah. She shares that Leah's family immigrated to the US 2 years ago and her parents have trouble communicating in English. She further notes that Leah's English language skills are below grade level, so she has difficulty following instructions or using academic language properly. Leah's parents do not attend parent-teacher conferences. Despite Ms. Jones' effort to include new science vocabulary on a Word Wall and carefully review new terms, she notices that Leah struggles and seems confused even about seemingly easy instructions. Ms. Jones does not know Spanish and has no idea how to help Leah keep up with her classmates.

She gives the PST an option to find ways to support Leah's learning. At this decision point, if the PST chooses to intervene, they are prompted to offer three ways to support Leah. This is followed by another prompt to justify them. If the PST does not intervene, they are asked to justify their decision. The scenario concludes with asking the PST to reflect on their role as a teacher, followed with additional questions that relate to their engagement with the scenario. Because these additional questions were not relevant to this study's research questions they were not included in the analysis. Figure 2 provides simulation snapshots from the Teacher Moments platform.

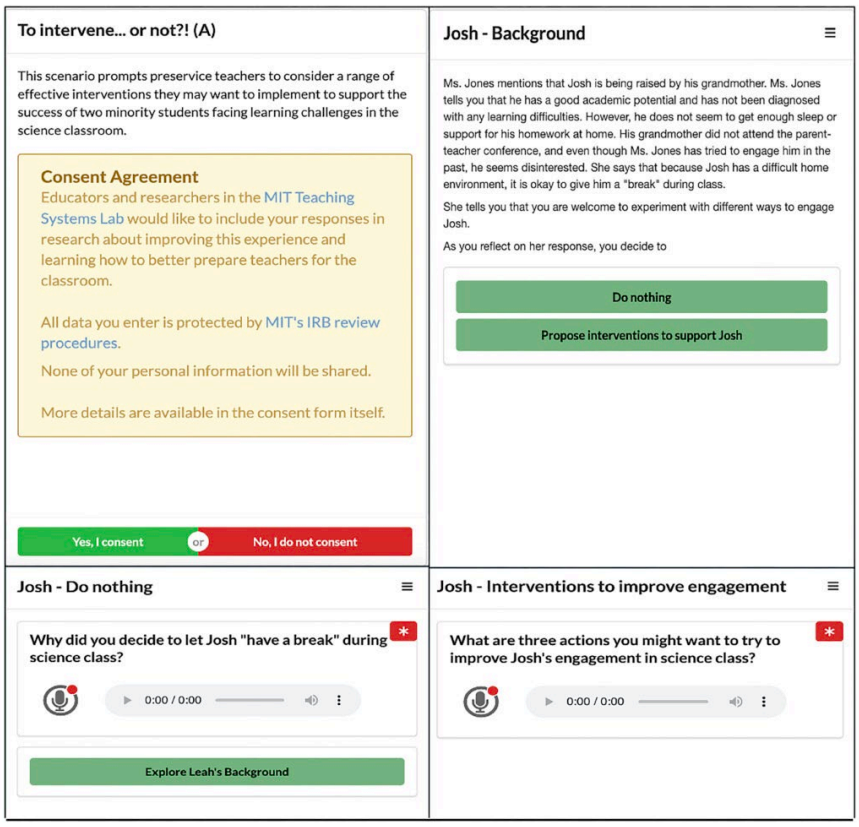
In setting up the simulation for data collection and analysis, the course instructor (first author), created a cohort link for each participating section, and set up the task as a course assignment shared with PSTs on the course's learning management system. Once PSTs accessed the simulation, the first page they encountered provided a consent agreement to which they must respond (see Figure 2, first image). Details of the simulation then proceed in the way described earlier. Each successive frame has new information or prompts the PST for a response. The PST audio records their response by tapping the microphone icon on the screen (Figure 2).

Study Participants

The participants consisted of elementary teacher education majors, mostly white females, enrolled in a science methods course in Year 3 in the elementary teacher education program. The simulation was assigned as homework during the 10th week of the semester (total 14 weeks) following

a previous class session in which PSTs read and discussed equity issues in science education (e.g., NGSS Lead States, 2013; Rodriguez, 2015).

Figure 2
Sample Screenshots From the Simulation as They Appear On the Teacher Moments Platform



Data obtained from 111 PSTs who consented for their data to be used were analyzed on three key junctures in the scenario related to PSTs' questions about the students' context, their interventions to support Josh and Leah, and reflections on their roles as teachers. Due to incomplete or missing responses, the number of analyzed responses differed across the various prompts. For example, for the questions prompt, data were analyzed from 101 participants. As for interventions, responses analyzed for Josh were from 91 participants, and those for Leah were from 89. For reflection on their role as teachers prompt, responses were analyzed from 100 participants.

Data Collection and Analysis

The simulation was authored and administered on the Teacher Moments platform. Data for consenting PSTs were retrieved, deidentified, and consolidated for analysis. Even though the PSTs' audio responses were converted by IBM's Watson, the authors checked PSTs' responses for transcription accuracy and corrected voice-to-text conversion before data analysis.

A qualitative descriptive design was used to identify salient features in PSTs' responses to the simulation prompts because it involves applying an interpretive, naturalistic approach to describe and understand the diversity of PSTs' ideas (Denzin & Lincoln, 1998). We described and interpreted PST responses using qualitative content analysis, as it is deemed appropriate for "focusing on the explicit description of the content of communication with a limited reflection on its implicit meaning" (Vaismoradi et al., 2016, p. 101).

Four main sets of PST responses were analyzed in this simulation. We read PSTs' responses for each data set and used open codes to classify their content. The first pertains to questions PSTs asked Ms. Jones as they explored potential reasons that might explain students' actions. The second set follows the decision point on whether to intervene on behalf of Josh and focuses on analyzing interventions PSTs proposed to support Josh's engagement. The third set followed PSTs' decisions as to whether to intervene to support Leah's engagement and analyzed their proposed interventions. Responses that included less than two interventions were considered incomplete/missing and excluded from the analysis. The fourth dataset pertained to PSTs' reflections on their teacher role.

We conducted an inductive content analysis by reading and open-coding PSTs' questions, their proposed interventions for each child, and their reflections on their roles as teachers. Similar open codes were grouped and used to establish categorical codes then compiled in the codebook (Saldaña, 2013). We coded the selected data independently using the established categorical codebook, assigning each proposed intervention to a categorical code.

Once we established the variety of types of interventions, we reanalyzed the data to include the type and the frequency of each type to document which types occurred more frequently than others. We discussed discrepancies and revised the codebook for clarification. We coded the data a second time using the revised codebook and calculated intercoder reliability for each dataset using Cohen's Kappa coefficient (Cohen, 1960). These values are reported with the results in Tables 2 and 4.

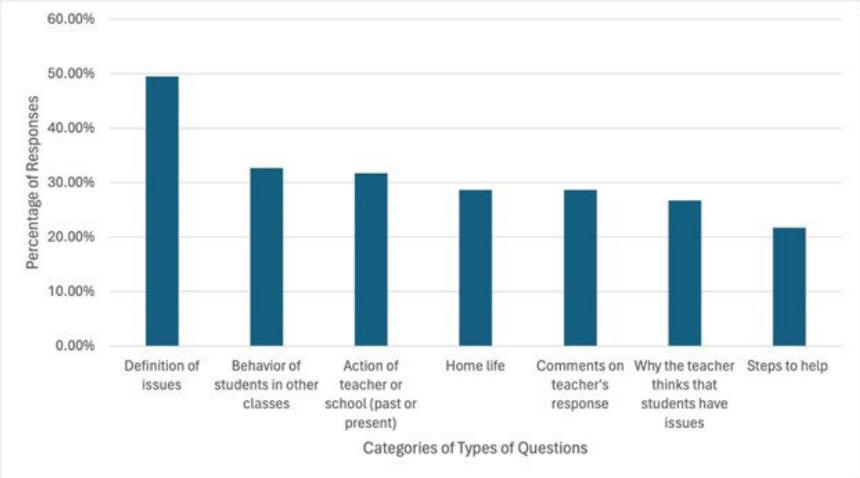
Results

Research Question 1

We classified PST's questions for Ms. Jones into six different types. The first category, "Definition of issues," refers to queries about what the teacher meant when she stated that the students have "issues." This category was the largest, with almost half (49.5%) of the responses inquiring how the teacher defined issues and what issues the teacher thought the students had. Almost one third (32.7%) of responses pertained to questions about current or past "Behavior of students in other classes." About a third (31.7%) of responses were grouped into the "Action of teacher or school (past or present)" category. Questions within this category focused on actions that Ms. Jones or the school might have previously tried with students, including any accommodations.

Almost a third of responses (28.7%) included questions about Ms. Jones, which fell into the "Comments on teacher's response" category. These responses expressed surprise at her lack of concern, passed judgments on her lack of action, or advocated for the students. The "Home life" category (28.7%) included responses in which PSTs wanted to know more about the student's home life or cultural background. About a quarter of responses (26.7%) were in the category of "Asks why the teacher thinks they have issues." The final category, "Steps to help" (21.7%), included responses about steps to take to help the students or how might the PSTs help the students. Figure 3 provides an overview of the types of questions asked.

Figure 3
Percentage of Responses by Question Type



The Cohen's Kappa interrater reliability coefficient between the two researchers was calculated for each category and ranged from .8 to 1, as detailed in Table 2.

Research Question 2

The types of interventions that PSTs proposed to support students' equitable engagement in elementary science fell into six distinctive categories: Relational, Curriculum and Instruction, Noncognitive Interventions, Peers, Support, and External Resources. The Relational category includes attending to the student's well-being, familial relationships, advocating and caring for the student, and culturally relevant pedagogy. The Curriculum and Instruction category captures interventions that modify content or instructional strategies, such as making content meaningful to students, using technology, allowing students choices, and adding visuals and hands-on activities. The Noncognitive category includes moving the student's seat, giving the student breaks, allowing them to take a walk, giving them a job in the classroom, and rewarding the student.

Table 2
Percentage of Responses in Each Question Category, Corresponding Cohen's Kappa Interrater Reliability, and Sample Responses

Category of Questions	Percentages	Cohen's Kappa Coefficient	Sample Responses
Definition of issues	49.5% 50/101	.92	"I want to know what specific issues the students have and how it affects their learning" PST50
Behavior of students in other classes and/or past	32.7% 33/101	.88	"I want to ask Ms. Jones if they do this during every subject. What differences she notices between each subject and also when I ask her if she's ever like sat down and talked to them because maybe there's something else going on.." PST108
Action of teacher or school (past or present)	31.7% 32/101	.94	"How long has this been going on? Have you asked why they seem unengaged? What have you tried so far?" PST77
Home life	28.7% 29/101	1	"I would want to know why she said the word issues I think she could have talked more about their social emotional status and kind of what was going on with that. I don't think issues is the appropriate word. I think she could maybe dive into more about what's going on with their home life, how their performance is in the classroom like grade wise and kind of maybe ask her what else she's noticed throughout the school year and what she does to help them when they're struggling or they get frustrated" PST65
Comments on teacher's response	28.7% 29/101	.80	"I want to know why she did not intervene and and [sic] just say they have issues" PST17
Why the teacher thinks that students have issues	26.7% 27/101	1	"Why do you say that? What "issues" are you referring to? Have you tried to help them before? If so, what worked and what did not work? How is their home lives? What are their stories?" PST47
Steps to help	21.7% 22/101	.81	"a few questions that I have Ms. Jones, one of the questions is why did she respond this way and what are we going to do to help the students? I think that it was wrong to use the word issues and that we need to worry about students and make sure that they're engaged in the classroom. So my question is focused on what can we do to help these students?" PST73

The Peer category includes interventions that mention placement with a partner or group work. The Support category is one-on-one support, such as pulling the student aside for extra help. The External Resources category includes the outside assistance of a social worker, English language learners (ELL) teacher, or paraprofessional and may include consulting other teachers for ideas. Table 3 presents examples of these categories.

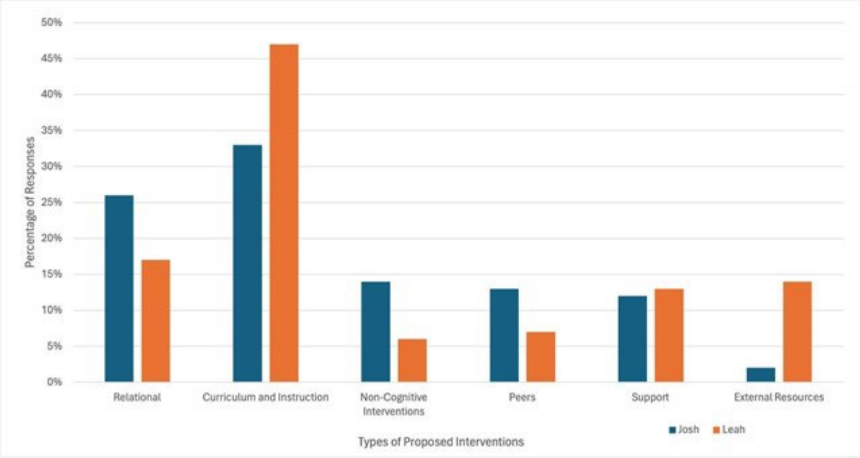
Even though interventions for both children were assigned the same codes, there was a marked difference in the extent to which PSTs referenced interventions along the Relational, Peer, and External Resources, reflecting how they interpreted the children's backgrounds relative to their prior knowledge and experiences. Some intervention categories were proposed at a higher percentage for Josh than for Leah and vice versa (see Figure 3). Examples of categories that were tapped at a higher frequency for Josh than for Leah were the Peers and Noncognitive interventions categories. The interventions proposed at a higher frequency for Leah than for Josh belonged to the Curriculum and Instruction and External Resources categories.

Table 3
Examples of Each Intervention Type

Intervention Type	Example for Josh	Example for Leah
Relational	"Trying to get to know him and who he is outside of school" PST75	"I would first try to learn certain words in Spanish to help communicate with her so she feels a little bit more comfortable." PST59
Curriculum and Instruction	"I would…try to relate the science to things that Josh cares about if there are things outside of class that are interesting to Josh then relating the science content to that Josh more interested. Another thing that I would suggest to the teacher…is encouraging more student-centered discussion instead of being lectured at Josh could be would be more beneficial for Josh" PST79	"You know when it comes to vocabulary words maybe you know giving Leah like a picture book to understand the words a little bit better because she can't really understand them in English…also using differentiated ways of teaching the material the student isn't going to understand it because she is does not speak English as well using pictures or videos or something that she can easily and more understand as well." PST67
Noncognitive Interventions	"I would take would be to allow him breaks when he needs" PST73	"Similar to Josh I think I would maybe give her a job in the lesson as the teacher's helper again so she really feels connected to the lesson and will better understand what's going on" PST32
Peers	"I might also ask him if he would like to work with his friends in class during assignments or	"One of the best interventions for ELL students is small group instruction or partner

Intervention Type	Example for Josh	Example for Leah
	activities to try to increase his motivation and engagement." PST66	activities because they can help learn off their peers and build off each other's knowledge and they may feel more comfortable in this type of environment rather than a whole class setting" PST6
Support	"The last action I may take to try…is to work with him individually so while the main teachers up there teaching I could sit with him and work to work with him through the science lesson that's going on at the moment and maybe he's like that because he's confused and he doesn't know science well so having a little bit of guidance may help him" PST31	"I would try and just sit with her trying to explain it as best I can try to keep her on track as best as I can give her some one on one time with other students are working on other independent assignments just trying to keep her on the same track as everyone else" PST107
External Resources	"The third way would be to getting in contact with someone who could support Josh and investigate what's going on at home that's causing him to lose sleep" PST 58	"The first thing I might do is approach the teacher and ask if there are any bilingual care professionals within the school that can come help support Leah during certain times of the school day just to give her some extra help." PST7

Figure 4
Comparison Between the Types of Interventions PSTs Proposed for Josh and Leah



These noted differences possibly reflect variations in PST's knowledge of or confidence in identifying suitable interventions for Josh and Leah. Cohen's Kappa interrater reliability coefficient ranged between .94 to 1 for Josh and .83 to .98 for Leah. Table 4 presents the percentage of proposed

interventions by type and the corresponding interrater reliability coefficients.

Table 4
Percentage of Types of Proposed Interventions and Corresponding Cohen's Kappa Interrater Reliability Coefficient for Josh and Leah

Types	% of Interventions (rounded)		Cohen's Kappa Coefficient	
	Josh *n* = 269	Leah *n* = 262	Josh *n* = 269	Leah *n* = 262
Relational	26%	17%	.94	.98
Curriculum and Instruction	33%	47%	.95	.98
Non-Cognitive Interventions	14%	6%	.94	.83
Peers	13%	7%	.97	1
Support	12%	13%	.94	.97
External Resources	2%	14%	.8	.97
Note. *n* = proposed interventions				

Two PSTs chose not to intervene in the case of Josh. PST97 justified their decision by stating,

> … some kind of break or going somewhere is definitely needed and allow [sic], should be allowed. We can't control what's happening at home, and as teachers in the classroom we just gotta try our best to make them get through it, you know.

PST110 justified not intervening on the basis that Josh "seems to be uninterested, and this lack of interest and tiredness just isn't bringing anything, it's taking away from the class and my instruction to the class." In the first response, PST97 expressed a sense of empathy that ends with considering giving the student a break as a valid option without considering its potential harm to Josh. In the second response, PST110 seemed to be more concerned about prioritizing the learning of the other students, coupled with resignation about Josh's disinterestedness. Both stances are concerning.

In the case of Leah, three PSTs selected the option to do nothing, but two proceeded to propose interventions. The third, PST23, justified not intervening by stating,

> …It is ok to do nothing in Leah's case because I was in her situation when I started learning English. It takes time to learn a new language. I learned English being placed in a normal classroom, and over time I gradually became better. It would be helpful if the teacher includes more visuals in the classroom to help Leah's learning.

Even though PST23 justified not intervening based on firsthand experience that things would turn out fine, they offered one possible intervention (such as using visuals). The decision of three PSTs to withhold or limit action instead of support student engagement is disconcerting and may be indicative of a weak equity mindset.

Research Question 3

The analysis of PSTs' reflections on their role as teachers showed that 69% of the PSTs conceived their role in terms of their responsibility to help students, while 22% of PSTs saw their role as providing resources to students. The remaining 9% of PSTs either commented positively on how realistic the scenario was or reported that they felt uncomfortable making recommendations to another teacher. Cohen's Kappa interrater reliability for these two categories was .81 for responsibility to help and .95 for providing resources.

PSTs who described their role in terms of responsibility to help often expressed an ethic of care (Noddings, 1988) that compelled them to support students. For example, one PST stated,

> I thought of my role as a teacher as someone who's there to help students armed with anything that that they need I want to be an advocate for them and show that I care and that if there's something that they need help with I'm always there to help them with it, and my goal is to get them to [the point] where they need to be to be happy with who they are and to be confident in their skills and abilities. (PST55)

Within this category, some PSTs focused on what they thought a "good teacher" should do:

> During the simulation I was kind of picturing myself as a teacher, so I think that that was helpful, because I tried to look at it through a teacher's perspective rather than a student teacher perspective in what would a teacher do and what, what [sic] a good teacher say. (PST12)

Others focused on a sense of responsibility to help, while also expressing disappointment at the classroom teacher's inaction:

> As a teacher I felt that I had to do something and that it was necessary for me to intervene for the betterment of my students. It was a little disappointing to me that another teacher, the head teacher, that I was with didn't do anything and didn't feel the need to do anything. (PST15)

PSTs who saw their role as providing resources or doing what is expected stated opinions similar to this example: "My role as a teacher in this simulation was to provide necessary resources to students who needed adjustments to their learning" (PST111). Some reflected on their role more generally: "I think my role as a teacher went well. I stepped in when I needed, and I intervened at the right times" (PST40).

Sixteen percent of PSTs included metaphors in their reflection on their role as a teacher. Fraser (1993) defined a metaphor as "an instance of the nonliteral use of language in which the intended propositional content must be determined by the construction of an analogy" (p. 332). Several PSTs included two metaphors, leading to a total of 21 metaphors. PSTs utilized the following metaphors: helper (n = 3), helping hand (n = 1), advocate (n = 2), caretaker (n = 1), support system (n = 4), supporter (n = 2), bridge (n = 1), tool (n = 2), problem solver (n = 1), guide (n = 2), and resource (n = 1). The following examples illustrate how PSTs used two of these metaphors (bold print) while reflecting on their roles:

> I very much thought of my role as **almost a bridge between the classroom and home life.** I think that I did that because I know how important and how great of an impact parental engagement has on the students, so if we are able to get them involved it might help the student, and I also kind of served, I think, as a support system both for the students and for the parents. (PST22)

> So, I think during the simulation I thought of my role as teacher as being **like a tool, just someone that was there to help support my students**. All students have different needs, and I think that my role as a teacher in this specific situation is to be there for my students and to find different ways to meet their needs. (PST 27)

Discussion

Using this digital clinical simulation in the elementary science methods course allowed the PSTs to consider actions they can take when encountering inequitable engagement in science. The variety of questions they asked and the types of interventions they proposed expressed distinct orientations to approaching the instructional dilemmas encountered in the simulation. Some PSTs focused on providing resources, while others appealed to higher moral grounds, in which resources are used to serve the larger good — the wellbeing of all children.

In both orientations, we gleaned evidence that illustrates two of the four dispositional qualities described by Liao et al. (2022) — namely, PSTs' awareness of inequities and positioning themselves as agents of addressing inequity. Further determination about the stability of the identified orientations or their potential to transfer from simulated to school-based experiences remains an open question for future research.

The theoretical framework undergirding this paper (Table 1) enabled us to fit some of PSTs' responses under seven elements of the education equity mindset (Nadelson et al., 2019). Their range of questions, proposed

interventions, and self-reflections on their roles provided a glimpse into their education equity mindsets as illustrated next.

Culturally responsive teaching:

> I think three actions that I might want to try to improve Josh's engagement in science class would definitely be, like, try to cater to his community and cultural assets. That way that he feels, like, represented within the curriculum and maybe see some things of interest. I think if he sees things he's interested in, he definitely [will] be more motivated to learn… (PST 70, Interventions)

Student-centered learning:

> … and there are many things that you do as a teacher for students who may have English as their second language or just struggle with that speech in general. One of the best interventions for ELL students is small group instruction or partner activities because they can help learn off their peers and build off each other's knowledge, and they may feel more comfortable in this type of environment rather than a whole class setting… (PST 6, Interventions)

Believes that all students can succeed:

> I want to find ways that Josh learns best to teach topics that interest him and allow him choice within the classroom. (PST 50, Interventions)

Takes responsibility for student success:

> Miss Jones, I really believe that we should be doing something about the matter. I noticed that you said they have issues but there's nothing that can't be fixed. I feel like the students have great potential, and we just have to find something that helps them becoming more engaged or would help them to become less confused or maybe find the assistance or tools that they need to do so. (PST 7, Questions)

Knows and understands student populations:

> I very much thought of my role as almost a bridge between the classroom and home life. I think that I did that because I know how important and how great of an impact parental engagement has on the students, so if we are able to get them involved it might help the student. And I also kind of served, I think, as a support system both for the students and for the parents. (PST 22, Reflections)

Believes in access for all:

> I thought of my role as a teacher, as a problem solver, as an educator. It is my job to make sure that every student in my classroom has an opportunity to succeed there all throughout the

> simulation [sic] was to problem solve and determine ways to accommodate the classroom to fix students' specific needs. (PST 46, Reflections)

Advocates for equity needs:

> I immediately want to know what the so called issues are. My another red flag that also comes up for me is why Miss Jones is dismissing them, is just taking their issues, "Oh, that's part of them. I don't need to worry about it." Obviously there's something going on that's bigger than just Josh keeping his head down, and I really want to know more about these students' backgrounds. I don't know if they have traumas that I should be aware of or just, like, biases that they have, and I also want to know Mrs. Jones' biases and why she's acting the way that she is. (PST 15, Questions)

There are noticeable differences between the responses of PSTs who expressed elements of care and advocacy or attention to student culture and community and others who did not. One could claim that the first group's expression of care may indicate a stronger education mindset. One could also claim that the second group's sense of care finds its expression in identifying specific and concrete actions. Therefore, inferring whether PSTs possessed a strong or weak education equity mindset from their responses to the various critical incidents may not be possible for three reasons: Potential variation in how PSTs engaged with the simulation, the relative brevity of PSTs' responses, and the lack of additional data sources for triangulation.

Thus, while it is possible to categorize responses within the education equity mindset and corresponding dimensions of engagement, equity, and diversity, data from PSTs' individual responses do not provide adequate details to determine if they hold a weak or strong mindset. The appendix presents a sampling of the variations in PSTs' responses to the different simulation prompts relative to seven of eight elements of an education equity mindset.

The theoretical framework employed in this study provided a valuable lens for interpreting PSTs' responses, even though PSTs' views are not static and are likely to be constantly evolving. Similar to findings on education equity mindsets of in-service teachers, PSTs' responses suggest that elements of an education mindset are possibly embedded, to varying degrees, in their thinking about teaching and learning (Nadelson et al., 2019). We did not examine the extent to which individual PSTs consistently addressed elements of the education equity mindset across their responses. Analyzing this component may help determine the extent to which these dispositions for equitable action are well-formed or remain in flux, even within a single, relatively brief experience.

Some PSTs used metaphors spontaneously while reflecting on their roles, making it interesting to compare their metaphors to those found in other studies that prompt teachers to reflect on their roles in terms of metaphors (e.g., Carlson, 2001; Leavy et al., 2007; Shaw & Mahlios, 2008). PSTs in this study used emergent metaphors, described by Craig (2018) as

"intuitively held and expressed… [that] naturally appear in a teacher's language and in his/her unfolding practice" (p. 302).

The emergent metaphor of "guide," mentioned by two participants, for example, has also been reported in another study (Leavy et al., 2007). From an instructional viewpoint, unpacking PSTs' metaphors during postsimulation debriefing sessions provides a productive area of pedagogical inquiry. Additionally, tapping into PSTs' metaphors throughout their teacher education program may enable tracking milestones in their teacher identity development (Thomas & Beauchamp, 2011) and assist them in critically reflecting on their instructional decisions while monitoring their growth and development. (Leavy et al., 2007).

Limitations

A main limitation of our study was the scope of collected data, which focused on PSTs' responses to the simulation's prompts. Obtaining additional data, such as surveys or follow-up interviews, could have allowed for a more elaborate analysis using multiple sources of evidence.

Conclusions

Findings from this study show distinctive orientations to ways PSTs perceive their roles as teachers following actions they proposed to improve student engagement in a hypothetical setting (i.e., digital clinical simulation). They also uncovered emergent metaphors the PSTs used to describe their roles as teachers.

Teacher educators can probe PSTs' orientations and metaphors and further explore these roles to support the coconstruction of productive actions that promote equity in elementary science. These findings have implications for course and program-level design in teacher preparation programs and for exploring the affordances of digital clinical simulations to advance the goals of equitable science education.. How can science methods and other teacher education courses provide carefully structured experiences (through simulations in various contexts) to strengthen PSTs' education equity mindsets across the teacher education program? How can course instructors, program coordinators, and school partners leverage school and community resources to support PSTs' understanding and enactment of equity-based practices?

This study contributes to the growing literature on the promising use of simulation-based learning in teacher education (e.g., Frei-Landau & Levin, 2023; Littenberg-Tobias et al., 2021; Sullivan et al., 2020). Specifically, it describes the types of interventions that a sample of elementary PSTs considered useful for supporting the engagement of minoritized students in a science teaching context. This study also raises questions about how simulations can be effectively structured in teacher education programs to enhance PSTs' development of strong equity mindsets.

Future research can explore the affordances of using digital clinical simulations to engender PSTs' formation of strong equity mindsets and

track the evolution of their emergent metaphors over time. Future studies may incorporate follow-up simulations with interviews to further examine PSTs' reflections on their roles or to compare the effectiveness of different equity scenarios in eliciting PSTs' development of pedagogical responsibility. Future research could investigate how simulation design features and their integration within teacher education programs can be optimally coordinated to maximize impact.

Acknowledgments

Special thanks to Garron Hillaire for his tremendous support and encouragement during the authoring and early implementation phases of the digital clinical simulation described in this study. The authors thank Louis Nadelson, Justin Reich, and Elizabeth Soslau for their thoughtful comments on an earlier version of this paper.

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Appendix

PSTs' Responses Addressing Different Education Equity Mindset Elements and Components of the Dimension of Engagement, Equity, and Diversity

Education Equity Mindset Elements and descriptions (Nadelson et al., 2022)	Engagement, Equity, Diversity (Rodriguez, 2015)	PSTs Statements Depicted From Their Proposed Questions, Interventions, and Reflection On Their Roles
Culturally responsive teaching	-Content is socially relevant (e.g., tied to everyday life and to students' concerns) (Engagement) -Content is culturally relevant (i.e., responsive to the classroom's cultural/ ethnic diversity and/or lack of it) (Diversity)	"after hearing what Ms. Jones says, I want to know what their family life is like, what I can do to help them to feel more comfortable in the classroom, maybe relate to their cultural background so that they can understand what we are learning" PST2 (Questions) "...if the students have never been engaged or seemed interested in the content, it could have been an issue if the lessons aren't culturally relevant to them…" PST30 (Questions) "I think three actions that I might want to try to improve Josh's engagement science class would definitely be like try to cater to his community and cultural assets, that way that he feels like represented within the curriculum and maybe see some things of interest. I think if he sees things he's interested in he definitely [will] be more motivated to learn…" PST70 (Interventions) "...prepare culturally relevant lessons that will pique his interest, engage josh during the lesson" PST42 (Interventions)
Student-centered learning	-A variety of pedagogical strategies are used within every lesson focused on student centered and collaborative learning (Engagement)	"since it sounds like Josh is a very hands-on student and maybe the disconnect is with learning regular academic material but since he seems to perk up and enjoy time during specials and recess, I would definitely want to try and incorporate a lot of hands on and just more engaging and fun science experiments and science discoveries in science class. I think that there are a lot of opportunities to go outside and incorporate the activities that Josh does seem to be interested in into the science class so I yeah the first action would probably be to try and incorporate more hands-on experiments and scientific discoveries try and take science class outside at points if that's available option and I also make sure I and Jesse is finding support in partner work would be best for Josh I was doing a lot more small group partner activities in science" PST82 (Interventions)

Education Equity Mindset Elements and descriptions (Nadelson et al., 2022)	Engagement, Equity, Diversity (Rodriguez, 2015)	PSTs Statements Depicted From Their Proposed Questions, Interventions, and Reflection On Their Roles
		"...I would… involve more hands-on experiments with science and everything else seems to not be engaging for him…" PST18 (Interventions)
	-Students work in small groups (Engagement)	"and there are many things that you do as a teacher for students who may have English as their second language or just struggle with that speech in general. One of the best interventions for ELL students is small group instruction or partner activities because they can help learn off their peers and build off each other's knowledge and they may feel more comfortable in this type of environment rather than a whole class setting…" PST6 (Interventions) Weak: "...Put [Josh] with a friend who is doing well in class and academically driven during group work to see if they can get him to come out of his shell" PST85 (Interventions)
	-Differentiated instruction is provided (Equity)	"You know when it comes to vocabulary words maybe you know giving Leah like a picture book to understand the words a little bit better because she can't really understand them in English…then also using differentiated ways of teaching the material the student isn't going to understand it because she is does not speak English as well using pictures or videos or something that she can easily and more understand as well." PST67 (Interventions) "I thought of my role as a teacher in terms of differentiated instruction and that each student is different and while the different things you plan for class may work for the majority of your students they're always going to be a few students who have outside factors contributing to the situation where they might need [more]. As their teacher I would need to really just sit down and think about different ways that I can differentiate instruction for them and help them become more engaged or to be more successful in the class and are contributing more" PST24 (Reflections)

Education Equity Mindset Elements and descriptions (Nadelson et al., 2022)	Engagement, Equity, Diversity (Rodriguez, 2015)	PSTs Statements Depicted From Their Proposed Questions, Interventions, and Reflection On Their Roles
	-A variety of grouping approaches are used (Equity)	“three actions to improve Josh's engagement in class, maybe I'd move him to another one of his friends, close to another one as friends, for example if he was close to a guy named Bob maybe I move next to Bob so that he could work with Bob during the science class because you know maybe this is the way to an improve his engagement because we'll be able to talk to the person feel comfortable. Second thing is maybe just calling him back to work with him individually at the back table and be his partner because this way I can get a sense of like how he thinks and also push him towards understanding the material and really like really being able to say his own perspective on it and another thing maybe have them work like in a group and give him a certain role because maybe this would help him like you know feels if it's important to contribute or important to really staying engaged in the class maybe even you know providing some visuals are some videos during the class on the content would help too because kids like visualizations” PST102 (Interventions) “I will keep an eye on him and remind him to focus on class. Also, I will put him in front of the class, which is sitting near by the teacher, then we can better watch him. The last one is make more group projects then he might be engaged in group but not the teacher.” PST106 (Interventions)
	-Students are encouraged to tie cultural/ethnic backgrounds to investigations/activities/ discussions (Diversity)	“once again I would definitely try to connect like the science material to her cultural community assets, especially cultural because there's definitely a gap between her home culture in her school culture and if we narrow that gap then she probably be less confused another thing I would do is maybe provide more visuals on like the instructions and stuff just so because pictures are universal language so everybody can understand what's going on in pictures and maybe try to use instructions that are more in her native language sometimes just to help her out proved that I want her to do the best you can and maybe also a home visit for Leah just to see what her home life is like” PST70 (Interventions) “during the simulation I thought of my role as a teacher as a supporter and a guide. I wanted to be there for the students and help them in any way that I could so I really took that into consideration and make sure I valued their own individual qualities and the background knowledge” PST96 (Reflections)

Education Equity Mindset Elements and descriptions (Nadelson et al., 2022)	Engagement, Equity, Diversity (Rodriguez, 2015)	PSTs Statements Depicted From Their Proposed Questions, Interventions, and Reflection On Their Roles
All students can succeed	-Students have choices in representations (Engagement)	"[inaudible] so like having students use different mediums for their project products things like that. If he's interested in sports or art will be able to maybe involved that is something that's my first action…" PST69 (Interventions) "I want to find ways that Josh learns best teach topics that interest him and allow him choice within the classroom" PST50 (Interventions)
Takes responsibility for student success		"Miss Jones I really believe that we should be doing something about the matter. I noticed that you said they have issues but there's nothing that can't be fixed. I feel like the students have great potential and we just have to find something that helps them becoming more engaged or would help them to become less confused or maybe find the assistance or tools that they need to do so." PST7 (Questions) "I would ask miss Jones…what issues do they have and how can I best support them within my classroom. Obviously they're my students and I want to give them the best chance at success as possible so not worrying about them would very much defeat this purpose" PST22 (Questions) "I would like to know why she said don't worry about them they have issues as her students it is her responsibility to be first of all respectful of them and whatever may be going on in their outside lives or their home lives, but also to work with them and have them be engaged and be learning just as all the other students are in their classroom" PST32 (Questions) "I kind of took that on as I need to figure out how to help the students because if one teacher is denying them basically the right to learn. I feel like there are many other teachers are doing that and I think that it's important to make sure that all of our students are getting access to…education and that they're getting access from other teachers as much as [possible]." PST10 (Reflections)

Education Equity Mindset Elements and descriptions (Nadelson et al., 2022)	Engagement, Equity, Diversity (Rodriguez, 2015)	PSTs Statements Depicted From Their Proposed Questions, Interventions, and Reflection On Their Roles
Knows and understands student populations	-Students have choices for representing knowledge (Engagement) -Accommodations are made to make the science classroom accessible to parents/guardians/ community leaders and elders. (Equity) -Students' family composition and variety of circumstances are seen as resources for building community and enhancing learning (Diversity)	"... the third thing you can do is try to include her cultural assets in the lessons you are teaching." PST14 (Interventions) "to improve Leah's engagement I would probably make sure that she that I am able to do something in order to engage her more engage her interests and her culture so I would try and find out more about our culture and use that to help me make lesson plans using materials inviting her culture in the classroom because I feel like this would be a good way to help or be more engaged…" PST35 (Interventions) "I very much thought of my role as almost a bridge between the classroom and home life. I think that I did that because I know how important and how great of an impact parental engagement has on the students so if we are able to get them involved it might help the student. And I also kind of served I think as a support system both for the students and for the parents." PST22 (Reflections)
Believes in access for all	-Each student has equal access to participate (e.g., accommodations are made for girls, ELL's, and students with disabilities to have equal opportunities to participate in and out of classroom activities/discussions) (Equity) -Differentiated instruction is provided for ELL's and students with disabilities (Equity)	"some questions I would have for miss Jones would be why do you think they have issues do they have any prior notation or evidence to assume that they have something getting in the way of their education well I would ask if they have an IEP or 504 I would ask if they have family troubles I would ask if they have any other special accommodations that I would ask to speak to their teachers from the year prior" PST13 (Questions) From questions: "some of the questions I asked miss Jones would be: what do you mean by issues? Do the students have developmental disabilities that I should be aware of? Do the students have behavior problems that could be addressed through changing the seating arrangement, lessons style, motivations etcetera. Is there a way we can accommodate the lessons to address these issues?" PST46 (Questions) "one of my roles as a teacher ask someone that was responsible for well-being and growth of my students and also I feel comfortable in the classroom" PST578 (Interventions)

Education Equity Mindset Elements and descriptions (Nadelson et al., 2022)	Engagement, Equity, Diversity (Rodriguez, 2015)	PSTs Statements Depicted From Their Proposed Questions, Interventions, and Reflection On Their Roles
		"I thought of my role as a teacher as a problem solver as an educator it is my job to make sure that every student in my classroom has an opportunity to succeed they're all throughout the simulation was to problem solve and determine ways to accommodate the classroom to fix students specific needs" PST46 (Reflections) "I thought in my role as a teacher as being an advocate for students by providing them with the proper supports instead of just leaving them to student centered learning when they don't have the supports and resources how about the effective for them" PST9 (Reflections)
Advocates for equity needs		"I immediately want to know what the so called issues are my another red flag that also comes up for me is why miss Jones is dismissing them is just taking their issues 'Oh, that's part of them I don't need to worry about it,' obviously there's something going on that's bigger than just Josh keeping his head down and I really want to know more about these students backgrounds I don't know if they have traumas that I should be aware of or just like biases that they have and I also want to know Mrs. Jones' biases and why she's acting the way that she is" PST15 (Questions) "I think we should help them…if we do not help them, who [is] supposed to help them?" PST106 (Questions) "I thought my role as a teacher by like having to think about my students and just making sure that I'm providing equal opportunities for all of them to succeed and showing them that I really care about them" PST70 (Interventions) "I thought it was role as a teacher or someone who's supposed to be an advocate for their students when you see that your students will be struggling you need help I think it's important that the teacher to take on my role as an advocate for the students and learn everything we can about students and do everything possible to help them succeed and become engaged" PST545 (Reflections)