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The Relationship between Teacher Candidates' Affective Dispositions and Instructional Planning Actions in STEM

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Abstract: This study explores the relationship between elementary teacher candidate affective dispositions and the action of STEM lesson planning. While affective dispositions are important, understanding the connection between dispositions and practice is key. Teacher candidates' affective dispositions about STEM education and instructional planning were examined after participating in a virtual STEM experience. Seventeen elementary teacher candidates experienced STEM instruction via summer virtual courses and field placements. This article focuses on responses to questions about affective dispositions that were coded using inductive analysis. Dispositions towards the following themes were identified: ways to teach integrated STEM, use of inquiry and open ended questions, and confidence. Early childhood lesson plans were coded deductively using the characteristics of model-eliciting activities. Analysis of the data found that teacher candidates who experienced learning, observing, and planning via virtual experiences demonstrated positive affective dispositions towards teaching STEM. However, there were areas of disconnect between the affective dispositions expressed and the instructional action of planning STEM lessons. The data suggest the experiences of learning, observing, and planning STEM lessons can be meaningful in professional growth, but that more needs to be done beyond these experiences to create synergy between instructional actions and affective dispositions related to STEM education.

Keywords: stem; early childhood; teacher education; preservice teacher; beliefs; planning; elementary

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1. Introduction

As society is becoming increasingly dependent on science, technology, engineering, and mathematics (STEM), it is vital that everyone develops STEM literacy to function in society [1]. The planned and enacted curriculum of public schools is intended to prepare learners to meet the demands of being productive citizens of society [2]. Teachers play a critical role in STEM education and early childhood educators lay the foundation for both content and affect towards STEM. Therefore, teacher preparation programs need to prepare teacher candidates (TCs) to provide students with quality STEM educational experiences [3,4]. This article aims to unpack the analysis of TCs self-reported affective dispositions towards STEM, their pedagogical action of planning for early childhood STEM experiences, and the relationship between these. Findings indicate that the virtual experiences of learning, observing and planning STEM lessons can be meaningful in professional growth, but that more needs to be carried out, beyond these experiences, in order for teacher candidates to consistently integrate the elements of STEM education into their instructional practices.

1.1. Integrated Science, Technology, Engineering, and Mathematics

It is critical for early childhood education to include opportunities for young children to engage in integrated STEM [5]. Yet, despite this need, there is not an agreed way to implement integrated STEM at the K-12 levels [6–8]. Bybee [9] defined integrated

STEM as real world problems where students use and connect the knowledge of two or more STEM disciplines to solve or understand them. It needs to include engineering because of its focus on problem solving and connection to the other STEM disciplines [10]. Integrated STEM education can be defined as using the engineering design process as the real world context for learning content within science, technology, engineering, and mathematics coursework [11]. STEM has also been defined using real world contexts to engage students in collaborative problem solving that uses big ideas and skills for at least two individual STEM disciplines [7,12]. Integrated STEM involves collaboratively utilizing multiple STEM disciplines to solve real world contextual problems, to increase STEM literacy among participants.

Being able to ask questions, collaborate with others, engage in the content, apply content, persist, appreciate, and comprehend how STEM concepts and skills can provide solutions to a variety of STEM challenges that cannot be solved by a single discipline, is the definition of STEM literacy ([13], p. 33). In a world increasingly driven by science, technology, engineering, and mathematics, it is vital to have a STEM literate population in order to function successfully [14]. For young children, environments that promote integrated STEM also promote valuable social–emotional learning [5], including "caring and respect, meaningful and rich contexts, iterative refinement of ideas and sensemaking, collaboration and collective thinking, meaningful assessment, and work to undo systemic oppression" ([5], p. S-4). Integrated STEM also helps children learn to participate in society by teaching them to investigate the world around them [15].

Despite the importance of engaging young children in STEM, research has shown that early childhood and elementary teachers are not adequately prepared to teach using integrated STEM pedagogies [11,16]. In fact, most research regarding integrated STEM has focused on the middle and high school levels [5]. There is very little research that examines early childhood preservice teacher education and using engineering to engage students in integrated STEM. One way that integrated STEM can be implemented in the classroom is through model-eliciting activities (MEAs) [17].

1.2. Model-Eliciting Activities

Model-eliciting activities (MEAs) are open ended problems based in a real world context where students engage in the engineering design process to find a solution for a client [17]. In engineering design problems, students are asked to design a solution that will improve a process or a product [18]. As students work to find their solutions to MEAs, they engage in the engineering design process by planning, creating, testing and revising their solutions [6]. The engineering design process is represented in Figure 1.

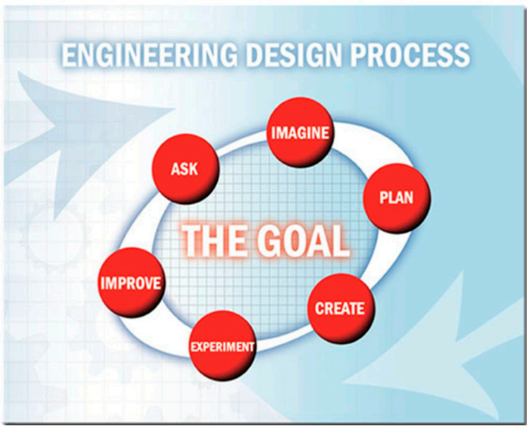

Figure 1. The National Aeronautics and Space Administration [19] represented engineering design as a cyclical process with six elements.

MEAs provide students with the opportunity to solve complex problems in a real world context using a natural connection between multiple STEM disciplines [17]. However, many teachers find it challenging to provide tasks based in a real world context, thus denying students the opportunity to learn in authentic ways [18,20]. In general, the engineering design process provides a context in which students can apply their knowledge of multiple STEM disciplines [21]. In addition, the engineering design process provides teachers with ways to connect the different STEM content areas and make learning more meaningful for students [22]. However, integrating STEM disciplines is often challenging for new teachers [18,22,23], especially those who are not trained as STEM educators [24]. During 2020 and 2021 many teachers had the additional challenge of teaching this content virtually for the first time due to the COVID-19 pandemic.

1.3. Virtual Learning

The coronavirus pandemic impacted teaching and learning in grades K-12 worldwide, as the physical closure of K-12 classrooms shifted many opportunities online. These closures and changes in instructional delivery methods affected 91.3% or 1.5 billion students enrolled in schools worldwide [25]. The pandemic created an opportunity to learn more about teaching online and the pedagogies being used [26]. However, many teachers were not prepared to shift their pedagogies and curriculum to emergency remote teaching [27,28]. Teachers who transitioned to online teaching during the COVID-19 pandemic perceived a lack of personal connections that foster motivation and engagement with online instruction [29]. They struggled to find ways to interpret and assess student thinking, monitor student needs and adjust in the moment. Conversely, Dhawan [30] suggests that technology should be leveraged to create a sense of community, meet individual student needs, and support purposeful inquiry and collaboration.

Professional development and teacher education focusing on using online teaching platforms and resources with all learners are critical in improving teachers' self-efficacy and usage [31–33]. In addition, more experience with digital technologies for teaching and learning is needed to prepare teachers for online instruction possibilities and help them see how this connects to their existing beliefs about teaching and learning [34,35]. These experiences are a key element to ensure the quality of online teaching [36] and increase efficacy [37].

1.4. Affective Dispositions Versus Actions in Planning

Many educators of young children lack confidence and preparation [38] or even face anxiety and fear [39] when it comes to teaching STEM content. These dispositions can have a ripple effect upon the experiences their learners have. We defined affective dispositions to be the attitudes, beliefs, and values that teacher candidates hold about teaching through integrated STEM. Ideas, perceptions, and values influence dispositions, because these can "be thought of as lenses that affect one's view of some aspect of the world" and are "psychologically held understandings, premises, or propositions about the world that are thought to be true" ([40], p. 259).

While self-reported dispositions are important, ultimately, the actions of teachers are what impact the learner. Therefore, it is essential to understand how dispositions impact action. The Council for the Accreditation of Educator Preparation [41] states how dispositions can impact performance. They define dispositions as, "the habits of professional action and moral commitments that underlie an educator's performance" [Dispositions section, para. 6].

Research has shown a connection between dispositions and the teaching practices implemented in the classroom [40,42,43]. The relationship between teachers' dispositions and reported practices is also true in STEM education [44,45]. Studies suggest that confidence in teaching STEM [46] and educators' selfreported readiness to teach STEM [47], positively influence educators' STEM education practices.

1.5. Elementary Teacher Candidates in STEM

One reason TCs may not have positive dispositions about teaching through integrated STEM is because they lack STEM experience [1]. The choices TCs make with their teaching, including interactions with students, are affected by the dispositions they hold [48]. For example, Philipp [40] found that TCs' dispositions about teaching mathematics change when they see children's mathematical thinking; this is also true for their dispositions towards STEM. Providing situations where TCs have positive experiences, both teaching and learning STEM, can impact their dispositions [4]. Elementary teachers, and, in turn, their students, benefit from strong teacher preparation and coherent professional learning opportunities and experiences with STEM education, to impact their dispositions and their actions [5].

1.6. Theoretical Framework

This study utilized situated learning theory as foundational to examine the beliefs, affect, and planning by TCs [49]. Situated learning theory has been widely used to explore connections between TCs' dispositions toward STEM in formal and informal learning settings [44]. Situated STEM learning occurs when STEM content and practices are integrated within a community of practice where authentic, relevant learning takes place [49]. This theoretical lens allows connections between the context of collaborative, authentic experiences with participant perspectives and actions. In our study, pedagogical strategies were modeled in an elementary methods course, which served as a professional learning experience [1]. In this professional learning experience, TCs were active learners and participated in activities in the same manner as their students [50]. This allowed TCs the opportunity to experience the STEM content knowledge and pedagogies they used in their classrooms as learners. This study extends the work by also examining the teaching action of instructional planning. The characteristics of MEAs that were examined are in Table 1.

Table 1. Characteristics of MEAs used in coding.

Characteristics of MEAs	Number of Lesson Plans Coded (n = 6)	%
Engineering Design		
Engineering design process	2	33
Constraints	3	50
Documents modeling process	4	67
Engineering in objective	1	17
Implied engineering by task	1	17
Missing test and revise	2	33
Open ended	2	33
Opportunity to collaborate	6	100
Opportunity to revise	4	67
Opportunity to share solutions	5	83
Missing engineering design	4	67
Integrates Mathematics, Science and Engineering		
Applies mathematics, science, and engineering	1	17
Includes mathematics and science	2	33
Includes science and engineering	0	0
Includes mathematics and engineering	4	67

Table 1. *Cont.*

Characteristics of MEAs	**Number of Lesson Plans Coded (n = 6)**	**%**
Missed opportunity for science	0	0
Missed opportunity for mathematics	2	33
Missed opportunity for engineering	2	33
Real world context		
Real world context	2	33
Context setting activity	3	50
Client driven	0	0
Missing real world context	2	33

2. Materials and Methods

2.1. Research Aims

This study aimed to deepen the knowledge about preservice teachers' affective dispositions and affect towards STEM education after experiences as learners, observers, and planners in virtual STEM experiences. It also examined the actual instructional action of planning STEM experiences among preservice teachers at the conclusion of these experiences. In addition, it sought to examine the relationship between the two.

2.2. Participants

Participants included 17 elementary teacher candidates (TCs) from two midsized universities: one in the western and the other in the southeastern region of the United States. Thirteen of the TCs were White, three were Hispanic, and one a Pacific Islander. Ten of the TCs were taking their first methods course, four were in the middle of their methods courses, and three were taking their last methods course. All TCs were enrolled in virtual summer courses for future K-6 grade teachers who participated in a 3-week virtual STEM camp field placement experience.

Students of the STEM camp were recruited from across the United States and included students from five states. The STEM camp focused on STEM processes, rather than specific content, due to the diverse student backgrounds and experiences. Two days during the camp focused on early childhood learners, two focused on intermediate level learners, and one day a week all learners participated in virtual field trips to learn about STEM in the workforce. The virtual STEM camp lasted for two hours each day. TCs were able to observe lessons being taught by teacher educators and wrote STEM lessons.

During the summer, the courses teacher candidates enrolled in provided opportunities to explore ways to effectively teach science and mathematics through real world, inquiry based integrated instruction, such as STEM lessons. Students engaged in STEM learning tasks during class sessions, observed and analyzed videos of elementary STEM lessons from the STEM camp and from online repositories, collaborated as TCs in planning and analyzing STEM lessons, and focused on the math, science, and engineering practices in course instruction and readings. A third party administered consent forms to all students enrolled in these courses. The third party stored them until after grades were posted, in order to avoid bias or persuasion based on power dynamics.

2.3. Researcher Positionality

The researchers were instructors in the courses and taught some of the virtual early childhood STEM lessons that were observed by TCs as part of their field component. The courses and field work were designed to introduce STEM education to TCs. The researchers, as course instructors, attempted to promote positive affect and experiences for TCs. This positionality is acknowledged, and the researchers tried to critically analyze their own lens for coding throughout the process. Therefore, interrater reliability was key in this study.

2.4. Instruments

Teacher candidates answered open ended questions about their beliefs and affect toward teaching STEM after the course and field work experience. The questions revolved around descriptions of STEM, confidence, experiences in STEM, and perceptions about teaching and learning in STEM. Some examples of questions asked are:

1. Think back to the Virtual STEM Camp you experienced. Describe an impactful activity you experienced during camp. How did it impact you?
2. How has your idea of STEM changed since helping with STEM Camp?
3. How would you define a "STEM lesson" for grades K-6? Do you believe your definition has changed since the beginning of the term? If so, how?

In addition, they submitted an integrated STEM lesson plan at the end of the semester. The lesson plans served as examples of their instructional action in lesson planning. These data sources were used for analysis.

2.5. Analysis

2.5.1. Affective Dispositions

For the open-ended questions about affective dispositions, we used an inductive approach to analyze data using systematic methods of data management through reduction, organization, and connection [51,52]. Initially, a code list was created using open coding by employing primarily descriptive coding to capture the big ideas in a word or short phrase [53]. The first cycle of coding illuminated an overall image of TCs' affective dispositions toward STEM education. Then, pattern coding was used for the second cycle of coding. This involved grouping and labeling similarly coded data to attribute meaning [53] after establishing inter and intra rater reliability [54]. Affective dispositions towards teaching the following themes emerged from the data: *ways to teach integrated STEM*, *use of inquiry and open-ended questions*, and *confidence*.

2.5.2. Lesson Plans

Integrated STEM lesson plans were collected at the conclusion of the virtual course and field experience to examine their instructional actions of planning effectively integrated STEM experiences. The course was designed for teacher candidates who would be certified in grades kindergarten through grade six, so not all lesson plans submitted by participants were intended for early childhood grades. Eleven were not coded for this study because they were written for grades above the early childhood grade range of prekindergarten through age eight, which is typically third grade. This range is based on the recommendations of the National Association of Educators of Young Children (NAEYC), which includes children from birth to age eight [55]. The remaining six lessons were coded using a scheme developed from the characteristics of MEAs: the integration of mathematics, science, and engineering; the engineering design process; and problem context. Since a pre-existing framework was used, the data was analyzed using content analysis [56].

Using deductive analysis based on concepts from MEAs, codes were consistently applied to the data [57]. The researchers independently coded eight lesson plans line by line to establish inter-rater reliability, which yielded 28 codes. When the 28 codes were applied to eight lesson plans, we disagreed in only three instances of the 163 codes assigned.

For both the dispositions and lesson plans, the author team consistently addressed discrepancies and reached an agreement on the codes. Inter- and intra-rater reliability were above 90%, which exceeded the reliability analyses minimum [54]. We set the standard for interrater and intra-rater reliability standards to 90% agreement. For both inter- and intra-rater reliability, all three researchers exceeded the minimum threshold of 90% needed for reliability analyses [54].

2.5.3. Connections between Affective Dispositions and Planning

Once themes were identified within the two data sources that represented affective dispositions and the instructional action of lesson planning, we examined the themes to find overlapping areas as well as areas that were illuminated in one area but conflicted with the other regarding the overall codes.

3. Results

3.1. Affective Dispositions

Initial data noted that not one teacher candidate had experienced integrated STEM as a learner or teacher in school settings, prior to this summer experience. Therefore, their dispositions on the postsurvey and their lesson plans reflected limited experience. However, there were many changes in thinking and reflections that provided insight into TCs' affective dispositions toward teaching. One candidate shared the following in her responses to the surveys:

I enjoy teaching lessons that include STEM disciplines. I love seeing the students' gears turn, seeing light bulbs go off, and connections being made. I like that STEM lessons naturally lend to discussion and include lots of class participation. I enjoy asking my students questions to further their learning in this area and see how they apply it to the real world.

This quote demonstrates affective dispositions from the three main themes that were identified from analysis of the open ended surveys: *Ways to teach integrated STEM, Use of inquiry and open-ended questions, and confidence.* Data about affective dispositions related to the three themes are described below.

3.1.1. Ways to Teach Integrated STEM

Key elements regarding affective dispositions towards integrated STEM involved valuing hands on experiences that connect across content areas and connect to the real-world contexts beyond simply the subjects being taught. One TC noted, "I loved every moment of learning and planning STEM lessons. Going through school, I never felt that lessons were applicable and useful for later in life... with STEM education students are able to apply these lessons to their own lives and interests . . . and understand how to make connections around them". This aligns with the TC who noted that, even in a virtual environment, "I was impacted by seeing the joy the students had while learning at STEM Camp".

Another shared, "STEM camp changed [my] thinking on teaching math by introducing many more real-life experiences into my lesson planning". She observed an integrated mathematics and engineering task for early childhood learners that was engaging for students because the topic (COVID) was connected to their lived experiences in a meaningful way and students were solving a meaningful problem to support others. She went on to explain how she was able to see how science and mathematics also could integrate in meaningful ways that support the learning of both content areas.

Recognizing how STEM skills can extend beyond STEM content was a powerful concept for one TC, who noted, "I've come to understand that STEM can cater to so many unique abilities and ways of thinking. I think STEM will also help teach students lessons that are not STEM-based, such as coping skills (keeping trying to solve the problem and deal with frustration), socio-emotional skills (collaborating and teaching each other), and work ethic (being responsible and supportive)".

Several noted that after experiencing hands on STEM learning, they see how it could have benefitted them as learners, so they see the need to pass this along to their future students. One shared that seeing the collaborations and "A-HA moments" created such joy for her and motivated her to want to provide these opportunities for learners. Others focused on the fun of STEM lessons.

3.1.2. Use of Inquiry and Open-Ended Questions

Student discourse, engagement, and productive struggle was recognized as an important part of the learning process. Eighty-eight percent of the students (15/17) specifically noticed the use of inquiry and open-ended questions in the lessons. One TC said, "I did appreciate how students were given open-ended questions and asking how they would better present the information for next time". One TC reflected that, although she had tutored a great deal in the past, she had never really planned or considered the importance of probing, open ended questions that help her understand student thinking, while also allowing space for students to consider their own thinking and push learning forward. A key takeaway from one TC was that "the parts where the students learn and grow the most are when they are actively engaged and asking questions on their own within the parameters of the task".

3.1.3. Confidence

A majority of the students reported increased confidence in teaching integrated STEM after the experiences of learning, observing and planning for STEM educational experiences. However, there was still concern among many, related to limited experiences teaching STEM to young learners. Confidence in one TC grew when she realized she could plan the questions to probe student thinking before teaching, so she could focus on the student responses during the lesson, rather than trying to think what she should say or do next.

One TC shared that, as a student, she never saw a real world purpose in her learning, but that, through this experience, she realized how important it was to connect learning to students' lived experiences. Therefore, she felt more prepared to make learning engaging and meaningful. Another shared that, before this semester, she lacked confidence because she had only seen worksheets used and doubted her role as a teacher, but that, through this semester, she saw the importance of empowering and scaffolding learners to make meaningful connections and felt more prepared to do this.

However, some did express concerns and lack of confidence as well, "I've never actually come up with a STEM lesson that someone else used in a classroom. I have created an integrated STEM lesson but don't know if it would be successful". She went on to say, "similar to any other component of teaching, I can put something down on paper, and it looks good, but it might not resonate the same way in the classroom". This was a challenge with the limited time in the course, because although TCs were able to observe, participate as learners, and plan lessons, they could not plan a lesson on their own and then teach it to early childhood learners. While the feedback showed an increase in confidence and a newfound enjoyment of STEM education, several expressed the desire for more experience implementing the lessons in order to grow in confidence.

3.2. Planning

Lesson plans were analyzed using content analysis based on content from the modeling eliciting activity conceptual framework to examine their instructional actions in planning for STEM instruction. The plans revealed four main codes: integration of subjects, the engineering design process, context, and collaboration.

3.2.1. Integration of Subjects

Teacher candidates demonstrated an awareness of integrating subjects in teaching STEM. Only one lesson applied science, engineering, and mathematics in their plans. This second-grade lesson engaged students with context by discussing a recent space launch and the force that is needed for that launch. Then students were challenged to design, construct, and test their own rockets. Then, students measured the distances as they launched them with great effort, medium effort, and lightly. At each phase of the plan students shared strategies and solutions with peers. This plan had integrated aspects of math and engineering and other aspects that integrated science and mathematics. It was the only plan that had engineering objectives listed, despite learning about the engineering standards contained within the Next Generation Science Standards [58] that teacher candidates used in their coursework and lesson plans.

Two lessons integrated mathematics and science. In one of these lessons, kindergarten students were asked to "count up to twenty dominoes which they will arrange in a line then, using an initial force students will knock down the line of dominoes causing the ball to move when the last domino falls and pushes it". This lesson integrated mathematics and science standards as noted below:

Science: Types of Interactions—When objects touch or collide, they push on one another and can change motion.

Math: Count to answer "how many?" questions about as many as 20 things arranged in a line, a rectangular array, or a circle, or as many as ten things in a scattered configuration; given a number from 1–20, count out that many objects.

Although this lesson asked students to build a chain reaction machine, which implicitly uses the engineering design process, the lesson does not ask students to use the engineering design process or scaffold any elements of the engineering design process, so there were missed opportunities to integrate engineering in the lesson.

While no lessons integrated science and engineering, four of the six early childhood lessons integrated mathematics and engineering. The central focus in one of these lessons was "Students will be able to create a straw tower using fewest materials and measure the height and width of the base and reflect on the potential improvements and strategies employed to create their structure". The standards that the lesson addressed focused on measurement and engineering, as noted below:

Math: Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.

Science: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3.2.2. Engineering Design Process

Only two lessons employed the entire engineering design process of asking students to design a solution, planning, creating, testing, and revising. Out of the two, only one explicitly noted this process with her learners, the other was implicit. The one that was explicit also noted each phase of the process, such as when students were planning and sketching their plans.

When examining individual elements of the engineering design process, more elements were noted. Two lessons involved an open-ended task of designing a solution and three had constraints within the challenges given. Four lessons involved documenting the planning and modeling process. Four lessons involved opportunities to test and revise along the way, but these were implicit, rather than explicitly noting them for learners, in all but one of these lessons. For example, one kindergarten lesson involved creating a domino chain with ten dominoes. The teacher candidate never noted that students would be testing and revising the chain if it did not work, but this would be necessary to achieve the final product. There were two lessons that missed opportunities for testing and revising that could have enhanced the learning environment. One plan involved the teacher describing every step of the creating process, rather than providing space for students to engage in the engineering design process. Student led learning was limited by not allowing the product to be designed through the engineering design process.

3.2.3. Context

Two lesson plans provided a real-world context for the content being explored. These two lessons also explicitly noted connections to engineering jobs and the work in the classroom. One of these plans began by introducing the role of a civil engineer and the engineering design process, and then challenging students to follow this process to design the tallest straw tower possible within specific constraints given in the challenge.

Although the other four all lacked this, two specifically missed clear opportunities for real world contexts within their plans. Not a single plan involved solving a problem for a client, which was often modeled in the model-eliciting activities that the teacher candidates observed.

3.2.4. Collaboration and Sharing Strategies

All lessons involved opportunities for collaboration and the sharing of strategies. Four of the six plans involved groups working together throughout the bulk of the lesson, while the other two provided opportunities for students to talk to peers as they progressed throughout the lesson in order to forward their thinking. Each plan involved times where teachers were asking questions to elicit student thinking and discourse. One plan had the teacher ask the students to share things that did not go well, revisions made, and what they liked about the solutions shared by peers.

3.3. Connections between Dispositions and Planning

Some consistent elements in lesson plans and selfreported affective dispositions were the focus on collaboration, sharing strategies, and the importance of teacher questions to elicit these opportunities from learners and to inform instruction. In addition, all lessons involved hands on activities, which were mentioned consistently in the affective disposition data. The engineering design process was only mentioned in three of the seventeen affective disposition responses and only appeared in two lesson plans, one implicitly and one explicitly.

Some inconsistencies included the use of real world context and meaning for learners in STEM lessons. Every teacher candidate noted the importance of real world context in their selfreported affective disposition and yet, only two of the six lesson plans written by the teacher candidates contained these elements.

4. Discussion

4.1. Discussion of Data

4.1.1. Affective Dispositions

Teacher candidates (TCs) reported that, although they did not have experience with STEM education prior to this experience, they were extremely positive about it at the close of the experience. Their lack of experience with STEM highlights the work that still needs to be done in preparing STEM literate citizens [1]. TCs valued the hands on experiences, the collaboration, the connection to real world contexts, the use of discourse inquiry and open ended questions that they saw as essential elements of STEM education. In addition, the benefits of STEM education beyond the content areas were noted by several TCs, with one specifically noting the benefit towards supporting social–emotional learning. This benefit aligns with research on STEM education [5,15].

Research has illustrated the lack of preparation and experience in STEM education for elementary and early childhood TCs [11,16] and the lack of confidence in teaching STEM [39]. This study provided these experiences and found the majority of TCs increased in confidence towards teaching integrated STEM. This indicates that the virtual learning, observing, and planning experiences positively impacted the overall affective dispositions of TCs towards teaching integrated STEM. However, the need for more STEM experiences teaching young learners utilizing this approach was noted as a tool to increase confidence.

Despite the research about virtual learning during the pandemic [29], this study suggests that the affective dispositions of teachers were enhanced from virtual experiences in learning, observing, and planning via STEM education. TCs expressed instances of collaborative learning, inquiry, and student voice throughout their courses and observations, as Dhawan advocates for when learning STEM online [30].

4.1.2. Lesson Plans

Lesson plans revealed some strengths in integrating subjects, but also highlighted areas for growth. For example, supporting teacher candidates in centering engineering and integrating more than two subjects, where appropriate. While integrated STEM can be two or more subjects, it always needs to include engineering because of its focus on problem solving and connection to the other STEM disciplines [10,11].

At some point in the lesson plan, four of the six lessons integrated math and engineering and two included math and science. However, not one lesson integrated science and engineering. Perhaps this is because the engineering and science standards used were part of the Next Generation Science Standards [58], so students may not have distinguished the importance and relationship between the two. It suggests that more opportunities to explicitly unpack the science and engineering standards from STEM lessons might support this area for teacher candidates.

Lesson plans highlighted the need for more focus and experiences in explicitly utilizing the engineering design process, as only two lesson plans contained the process and only one explicitly named the elements of the engineering design process. Many elements of the engineering design process were in other plans, but mostly these were implied within the activities and plans, rather than being fore fronted for learners in a systematic way as suggested by many [11,17,18].

Lesson plans lacked real-world contexts within a majority of the tasks in which learners engaged. This also connected to the data that there were no tasks designed for students to report or create a solution for a client, real or fictional. STEM tasks or problems need to be in context for students to meaningfully engage with the content and see how STEM skills are needed beyond the classroom [7,20,21]. However, studies have noted the lack of authentic experiences and tasks within many classrooms [22,23]. In order for teachers to value, plan and implement authentic learning experiences with their learners, they could benefit from experiences as learners and teachers in these positive learning settings. Such authentic learning experiences helped to create STEM knowledgeable students who know how to be innovative and creative thinkers.

An interesting observation is that both the coursework and the field experiences were all conducted virtually for students, so they were virtual learners and were able to see young children learning STEM virtually. However, despite all experiences being virtual, not a single early childhood lesson plan involved children utilizing technology. This did appear in some of the intermediate lesson plans, but those were not coded or included in this study, since it focused on early childhood learners. The literature suggests that experiences such as the ones TCs experienced are essential in improving TC self-efficacy and likelihood to use technology online [31–33] and see its connection to their affective dispositions regarding teaching and learning [34,35]. When asked about their experiences learning and observing in virtual settings, TCs noted the engagement, positive experiences, community, etc... However, they did not apply this in their own planning. Follow up interviews with teacher candidates about their instructional choices to not utilize technological resources in their lesson plans would be an interesting addition to this study.

Early childhood experiences in STEM education set the foundation for student attitudes, beliefs, and knowledge in STEM. Teachers are critical in these experiences and therefore their affective dispositions and actions are important to explore. Finding ways to support these areas in teacher education programs can positively impact future learners. Teachers and teacher candidates need to be supported in designing science and engineering learning environments and engaging in practices and pedagogies that support the full range of learners in their classrooms [5].

While some of the affective dispositions noted by TCs were illuminated in their instructional actions in lesson planning, others were lacking, such as the connection to real world contexts and utilizing the engineering design process. These align with other studies that share the challenges of teaching in these areas.

4.2. Limitations

A limitation of the study is the sample size. The small numbers provide insight into the TCs in the study but cannot be generalized. In addition, this only explores the effect and planning during one semester. A longitudinal study could show if these effects remain consistent or change over time. In addition, a study exploring other aspects of action, such as instruction and assessment, could be useful. In addition, connecting initial individual student responses and plans with those at the end of the semester could provide more specifics that could benefit understanding how the affective dispositions align or misalign with their instructional actions.

5. Conclusions

This study illuminated the importance of providing early childhood teacher candidates with positive STEM learning and planning experiences. Data indicates that these experiences can increase confidence and other affective dispositions. While it can be conjectured that this experience informed the lesson plans that TCs created at the end of the experiences, there were areas on these instructional artifacts that indicated the need for more opportunities to deepen understanding and connect their values to the action of teaching using an integrated STEM approach.

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