Using Concept Maps to Analyze Educators' Conceptions of STEM Education

Jennifer R. Simons
George Mason University

Abstract

This study analyzes educators' conceptions of STEM education at the beginning of an online graduate course for in-service teachers. It offers a qualitative thematic analysis of educators' initial conception of STEM education and their roles as STEM educators through the use of concept maps and reflection statements. Conceptions of STEM varied greatly across the sample and fell into seven categories: (a) utilitarian, (b) acquisition of disciplinary knowledge, (c) activities and resources, (d) meaningful problem-solving experiences, (e) advocacy for systemic change, (f) buzzwords, and (g) educator's role in STEM teaching and learning. This study reveals the complexity of educators' ideas of STEM and educator roles within STEM education. Using concept maps as formative assessments can better position teacher educators to provide structured reflection space for educators while aligning coursework and resources to better meet educators' varied needs.

Keywords: teacher education, STEM education, teacher conceptions

Since its inception, STEM education has become a national priority in PK-12 schooling (National Academy of Engineering [NAE] & National Research Council [NRC], 2014). Viewed as a way to increase national power and prosperity, STEM education is tied to national goals and policy (Granovskiy, 2018). STEM education is also tied to more equitable and supportive learning environments, giving learners broad access to learning (Peters-Burton & Knight, 2022). Given the economic, political, and equity-related outcomes of STEM education, it is no wonder that federal legislators have prioritized STEM education initiatives, introducing over 300 bills related to science education from 1997-2018 (Granovskiy, 2018). While science education and STEM education are not inherently interchangeable, many agencies and legislative bills transpose the two concepts. Despite this lack of consensus on the definition of STEM education in PK-12 education, federal and state agencies prioritize funding STEM initiatives (Vasquez, 2015). U.S. federal investments in STEM education are estimated to amount to $3 billion annually, although the number is difficult to estimate due to different agency definitions of STEM education (Granovskiy, 2018). While the U.S. government's valuation of STEM education is apparent, there is no consensus on what STEM education means.

Federal definitions range from the generally broad definition of STEM used by the National Science Foundation that includes psychology, social sciences, physical and life sciences, and engineering, to the more narrow definition from the Department of Homeland Security that only focuses on mathematics, chemistry, physics, computer and information sciences, and engineering (Granovskiy, 2018). Even education researchers face difficulty defining STEM education but have reached some consensus. In the broad spectrum of STEM definitions, several common goals can be found: STEM education should use real-world contexts, focus on student-centered pedagogies, support 21st-century skills, and encourage reflective citizens' development (Bybee, 2018; English, 2017; Margot & Kettler, 2019; Moore et al., 2020; Nadelson & Seifert, 2017). The STEM disciplines share concepts, skills, and practices that can be transferred across disciplines (Moore et al., 2020), which students need to develop as global citizens and be prepared for STEM careers (Koehler et al., 2021). Even with these common goals, the pathways to achieve them are contested with implementations of STEM education ranging from a single discipline focus emphasizing science, technology, engineering, *or* math to a transdisciplinary focus that must include all four disciplines in an integrated fashion (Bybee, 2018).

This ambiguity extends to educators' conceptions of STEM education (Dare et al., 2019), as educators have varied STEM experiences and views on what integrated STEM is and how it should be implemented (Holincheck & Galanti, 2022). Although many educators may not be able to define STEM education clearly, they have a sense of what it is not, rejecting overly vague and simple disciplinary models (Dare et al., 2019). Complicating matters for educators is the push towards "STEM for all." On its face, "STEM for all" is a seemingly beneficial way to engage minoritized students in STEM subjects and encourage their growth as future STEM professionals (Handelsman & Smith, 2016). However, "STEM for all" creates a false universality that outwardly declares STEM is for all students when many students' experiences show that science is indeed just for some (Sheth, 2019). The systemic inequities inherent in STEM education are often invisible due to their regularity. As teachers implement initiatives like "STEM for all," they may unknowingly subject students to injustices due to commonplace teaching practices (Calabrese Barton & Tan, 2020).

As the individuals responsible for implementing many STEM education initiatives, knowing how educators conceptualize STEM education is imperative for administrators, teacher educators, researchers, and policymakers (Navy et al., 2020). This research offers a qualitative thematic analysis of educators' initial conceptions of STEM education and their roles as STEM educators through concept maps and reflection statements.

Literature Review

The importance of STEM education has only grown since the launch of Sputnik in the 1950s (Granovskiy, 2018; Koehler et al., 2021). Following the grim picture of American science and mathematics education identified in the *A Nation at Risk* report (Gardner, 1983), U.S. researchers and curriculum developers began a trend to integrate science, engineering, technology, and mathematics components (Koehler et al., 2021). What was once seen as a geopolitical statement is now seen as an economic amplifier. The America COMPETES Act (2007) and its reauthorizations (America COMPETES 2010, 2022) showcase the importance of

STEM jobs to national economic security. Furthermore, STEM education is one of the main sources of STEM knowledge and skills for the American public. As such, the federal government spends around $3 billion yearly on STEM education initiatives and closely watches indirect metrics of STEM education success, including student success on international science and math exams and the number of students completing STEM degrees (Granovskiy, 2018). STEM literacy is often seen as a pathway toward social and economic well-being (Mohr-Schroeder et al., 2020).

Although economic factors are often cited as why we should teach STEM, there are more student-centered benefits to increasing students' STEM literacy. These benefits include making students better innovators, inventors, problem-solvers, and logical thinkers (Morrison, 2006). Stohlmann et al. (2012) maintain that integrating STEM disciplines positively impacts students' interest in school, motivation to learn, and achievement. Additionally, integrated curricula improve higher-level thinking skills and retention (Stohlmann et al., 2012). Further benefits of STEM education include strengthening students' ability to transfer and connect knowledge across disciplines, gaining practical experience, and developing technological skills (Martín-Páez et al., 2019).

As a vehicle of economic success and deeper student learning, STEM has also been championed as a way to advance equity. However, its success is still unproven (Bullock, 2017). Historically, anti-Blackness within schooling has affected students' access to equitable STEM learning opportunities, further reshaping their academic possibilities in secondary and post-secondary education (Madkins & Morton, 2021). Some, primarily White, students' ideas and lived experiences are centered over those of other, often minoritized, students (Sheth, 2019). This impacts career options later in life, as Black and Hispanic workers are significantly underrepresented in the science and engineering workforce in the United States (Le & Matias, 2019). However, only fixating on inequitable outcomes subverts attention from the underlying systemic inequities in STEM education and its implementation in classrooms (Le & Matias, 2019).

Difficulties in Defining STEM Education

Considered by policy-makers at national, state, and local levels as a way to continue prosperity and progress in the global marketplace by preparing future STEM professionals (Roehrig et al., 2021), STEM has been used as a framework to integrate the disciplines to better reflect today's complex problems and interdisciplinary solutions (Bybee, 2018; English, 2017). STEM education is a national priority (NAE & NRC, 2014), yet there remains a lack of consensus on what STEM means or how to implement it (Bybee, 2018; English, 2017; Moore et al., 2020). At times, STEM includes only one of the four disciplines. Some interpret it as four distinct, equally important disciplines. Others contend that STEM requires intentionally integrating several of the four disciplines (English, 2017; Moore et al., 2021).

Today's problems are increasingly complex, and their solutions require the integration of multiple disciplines, concepts, and skills (Roehrig et al., 2021), yet there remains debate on the conceptualization of STEM integration in PK-12 education (Bybee, 2018; Moore et al., 2020). Moore and colleagues (2021) contend that it must include five pedagogical practices: (1) the content of at least one science and mathematics discipline defines some of the primary learning goals; (2) engineering practices and engineering design of technologies acts as the integrator; (3) scientific and mathematical concepts are linked to the engineering design or engineering practices through design justification; (4) 21st Century Skills are emphasized; (5) the instruction requires solving a real-world problem or task through teamwork. However, contextual barriers, including pedagogical challenges, curriculum constraints, and inflexible structures, can make integrated STEM difficult to implement universally (Holincheck & Galanti, 2022; Margot & Kettler, 2019; Nadelson & Seifert, 2017; So et al., 2021). In response, Nadelson and Seifert's (2017) spectrum of STEM promotes a mixture of segregated foundational knowledge with integrated STEM pedagogy and provides a flexible template for overcoming contextual barriers.

As a current secondary science educator in a doctoral program, my experience informs my assumptions about integrated STEM education and its implementation. I draw upon Nadelson and Seifert's (2017) definition of integrated STEM as "the seamless amalgamation of content and concepts from multiple STEM disciplines… considered…in the context of a problem, project, or task" (p. 221). Following the commonalities across the field, I also extend my definition to include using real-world contexts, student-centered pedagogies, and supporting 21st-century skills (English, 2017; Margot & Kettler, 2019).

Importance of Teacher Conceptions of STEM Education

Educators work in the tension between how STEM is used in common parlance and how it is incorporated into educational environments (Navy et al., 2020). The ambiguity surrounding STEM makes communicating expectations for educators problematic (Dare et al., 2019). Integrated STEM initiatives have grown in popularity, although their success largely depends on an educator's ability to connect the disciplines explicitly (Dare et al., 2018). Building educators' STEM content knowledge is crucial as it positively correlates to educator efficacy, confidence, and comfort in STEM content (Margot & Kettler, 2019). Successful STEM integration includes explicit teaching of STEM concepts and STEM processes (Kelley & Knowles, 2016).

Pedagogical changes are also necessary: STEM pedagogy requires a shift from the sage-on-the-stage mentality towards the guide-on-the-side (Margot & Kettler, 2019). To foster creativity and increase engagement, educators may benefit from the meddler-in-the-middle role, which involves the educator providing support and direction through activities in which they are also involved, re-positioning educators and learners as partners in learning (McWilliam, 2009). Educators should also have the guidance and support to confront the inherent inequities in STEM education (Le & Matias, 2019) because teachers are unlikely to change their pedagogy if their conception of content has not changed (Ring-Whalen et al., 2018). As ongoing professional learning opportunities addressing content and pedagogical concerns influence educator practice and implementation of STEM education, teacher educators must develop tailored learning opportunities for educators to feel supported in STEM implementation (Margot & Kettler, 2019).

Kelley and Knowles (2016) argue that professional learning opportunities should incorporate a strong conceptual framework of STEM education to help educators build confidence. They advocate for explicit teacher learning on key learning theories, pedagogical approaches, content knowledge, and current STEM educational research inclusion within educator practices (Kelley & Knowles, 2016). There is a critical need to identify how teachers conceptualize STEM education in order to support them in its implementation, yet there is limited evidence of teachers' conception of STEM education in a professional learning context (Dare et al., 2019).

Method

This study attempts to understand educators' pre-existing conceptions of integrated STEM education and their roles as educators in STEM. The following research questions guided this study:

(1) How do concept maps as formative assessments reveal how educators view integrated STEM teaching and learning?

(2) What do educators view as their role in integrated STEM teaching and learning?

This study builds upon previous work by Holincheck and Galanti (2022) by analyzing concept maps as formative assessments. Concept maps have the unique ability to capture the layering of ideas, connections, and the depth of language based on prior experience (So et al., 2021).

Participants

A total of six educators participated in this study. Participants included high school educators (n=2), middle school educators (n=2), an elementary educator (n=1), and a pre-service educator with high school substitute teacher experience (n=1). Of the six participants, five had fewer than four years of experience as educators, while the remaining educators reported 11 years of experience. Participants taught math (n=2), science (n=2), general content (n=1), and English (n=1).

Study Context and Data Collection

Participants in the study were enrolled in an online graduate-level course on STEM education, which was part of a graduate education program for in-service teachers at a large public university in the mid-Atlantic. It is an elective for an advanced master's degree program in teaching and learning for PK-12 educators and was primarily taught asynchronously. Learning objectives centered on Nadelson & Seifert's (2017) definition of integrated STEM teaching and weekly modules and assignments challenged students to identify and apply methods to teach integrated STEM, emphasizing equitable access.

The data analyzed were collected via a purposeful set of asynchronous activities during the first week of the course. Following Holincheck and Galanti's (2022) protocol, students answered the open-response question, "Do you consider yourself to be a STEM teacher? Why or why not?" To activate prior knowledge, they were assigned readings on STEM integration (Vasquez, 2015) and equity in STEM (Mensah, 2021) and then asked to draw a concept map. The prompts for the concept map were changed from (1) What is your understanding or conception of *STEM education*? [emphasis added] and (2) What do you see as the most important ideas and sub-ideas? (Holincheck & Galanti, 2022) to (1) What is your understanding or conception of *STEM teaching and learning?* [emphasis added] and (2) What do you see as the most important ideas and sub-ideas? While the original goal of capturing personal and professional perspectives about STEM teaching and education remained, the wording was changed to intentionally focus on the teaching and learning processes rather than the education system.

To further develop my understanding of the educators' conceptions of their role as a STEM educator, open-response questions were asked at the conclusion of the course and included "Do you consider yourself to be a STEM teacher? Why or why not?" as well as "Do you think others see you as a STEM teacher? Why or Why not?" Responses were used to provide further context for the educators' views on STEM education.

Data Analysis

Concept maps were analyzed using in vivo open and descriptive coding, allowing me to examine the language used, the nature of the words (e.g. nouns, action verbs, and descriptors), and the connections between concepts. (Saldaña, 2021). Analysis of emergent themes permitted the usage of the six final themes from Holincheck and Galanti's (2022) previous study, with the addition of a new category: educator role in STEM education. Responses to the open-ended questions "Are you a STEM teacher? Why or why not?" were used as supporting data to provide further context to the concept maps.

Using the framework established by Holincheck and Galanti (2022), six categories of teacher conceptions within the concept maps were identified. Data analysis required the addition of the educator role category for a total of seven categories. Overall, each of the concept maps focused on one or more of the following aspects of STEM education: (a) utilitarian, (b) acquisition of disciplinary knowledge, (c) activities and resources, (d) access to meaningful problem-solving experiences, (e) advocacy for systemic change, (f) buzzwords, and (g) educator role in STEM education. Each concept map represented at least one theme, while several encompassed several themes, showcasing the educators' ability to hold various conceptions of STEM education.

Findings

Analysis of concept maps revealed a consistent use of terms and connections. Each individual's maps fit into at least one of seven categories. While each map exhibited a strong pull towards a particular category, most maps touched upon multiple categories.

Utilitarian

Teachers with a utilitarian view of STEM education focus on STEM careers and the practical or economic benefits of focusing on STEM. Two of the six concept maps explicitly included careers or future workforce considerations (see Figures 1 and 2). One included long-term benefits and higher-paying jobs as part of being a STEM student (see Figure 1). The second (see Figure 2) included the future workforce as part of being a STEM student. That only two concept maps explicitly noted STEM careers is surprising, as much of the focus on STEM has been career-readiness (Roehrig et al., 2021). One educator (see Figure 3) included industry and its funding of STEM education, noting that industry values a STEM-literate future workforce.

Acquisition of Disciplinary Knowledge

Teachers with a disciplinary view of STEM education focused on science, technology, engineering, and/or math individually rather than STEM as an integrated discipline. Four educators included the four disciplines in their concept maps. Of those, two created their own main topic of "content" with no connections to other concepts, thus removing the disciplinary content from any context (see Figures 1 and 4). The remaining two placed the four disciplines under the heading of STEM teacher or educator, indicating the educator as primarily responsible for discipline-based content delivery (see Figures 2 and 5). No interdisciplinary linkage occurred across the four that included the disciplines, indicating a traditional siloed view of the content areas. Several maps included "cross-curricular" (see Figure 5), "interdisciplinary," transdisciplinary," and "multidisciplinary" (see Figure 4). Both individuals treated those terms as buzzwords, with no connections or linkages to show a deeper understanding. One educator embraced an interdisciplinary approach and explicitly mentioned collaborating with colleagues to make learning interdisciplinary (see Figure 6). Interestingly, this educator primarily taught high school English but indicated a desire to bring STEM skills into their class.

Activities and Resources

Teachers who represented STEM as an amalgamation of activities and resources illustrated a teacher-centered view prioritizing tools and methods over problem-solving. Basic pedagogical tools that could be used in any discipline were commonly used, such as addressing misconceptions (see Figure 5), backward design (see Figure 6), and hands-on learning (see Figures 1, 2, 5, and 6). While all the stated pedagogical tools are useful in STEM education, they are not a significant component of STEM nor used exclusively in STEM education. One educator drew a connection between industry supplying materials for STEM educators and was the only one who connected STEM teaching and learning to industrial stakeholders (see Figure 3).

Access to Meaningful Problem-Solving Experiences

Teachers who view STEM as access to meaningful problem-solving experiences focused on student-centered learning through engaging and immersive opportunities connected to real-world problem-solving. Real-world problem-solving experiences are one of the main goals of STEM education, and it was promising that most of the educators included this in their concept maps. While five educators mentioned problem-solving or project learning (see Figures 1, 2, 4, 5, and 6), only two expanded their thoughts or explicitly linked to other concepts. This may suggest a positive view of the concept but a lack of understanding of *how* to implement it in the classroom. Of the two that expanded upon problem-solving and immersive experiences, only one, an English teacher, focused on "real world" problems and noted that "students learn from their mistakes," which leads to "real learning happen[ing]" (see Figure 6). The sole elementary educator included "real world learning" with "funds of knowledge," "identity exploration," and "problem solving with peers" as important concepts under "STEM student" (see Figure 1). This suggests a student-centered mindset, although, in the open-ended survey response, this educator flatly denied being a STEM teacher as "we have a STEM teacher at the school I work at."

Advocacy for Systemic Change

Educators predisposed to advocate for systemic change viewed STEM as key to addressing equity. While four concept maps referenced making instruction culturally relevant or advocated for students using funds of knowledge (see Figures 1, 2, 4, and 5), most teachers who used the terms provided no context for them and failed to link them to other concepts, perhaps demonstrating an awareness of the vocabulary without an understanding of what it would mean to engage in culturally relevant teaching practices in STEM. One educator provided additional context and depth to culturally relevant instruction, noting the importance of both "incorporat[ing] students' culture and background knowledge" and "knowing their students" (see Figure 1).

An additional participant, a pre-service educator, acknowledged the barriers inherent in STEM education (see Figure 3). Seemingly cognizant of the systemic barriers in place, this educator labeled a dashed line "forms barriers." This dashed line begins with money, culture, and government and separates STEM students from STEM education and industry. This educator was also the only one to acknowledge governmental and industrial influence on STEM education. While this student focused on systemic issues, they did not include students, teachers, or pedagogical concerns on their map.

Buzzwords

Educators with a buzzword conception described STEM as a collection of words without meaningful connections. Many words, such as cultural relevance, transdisciplinary, and problem-based, were recycled from the readings without contextualizing them. Three concept maps show evidence of buzzword thinking indicating interest in STEM but an inability to conceptualize what it may look like in a classroom. One concept map, in particular, was comprised mainly of buzzwords floating outside main concepts (see Figure 4). This educator clarified in their reflection that they viewed themself as a STEM teacher because they "incorporate interdisciplinary teaching into all my classes," however, their concept map suggests a lack of understanding of the application of STEM initiatives.

Educator Role in STEM Education

Integrated STEM education requires a mindset change from teacher-led instruction to collaborative meddling (McWilliam, 2009). It was heartening that three of the six concept maps included a relationship between the educator and the learner. One showed a linkage noting "we teach each other!" above the connection (see Figure 6). The other two incorporated a much more cyclical relationship where the educator creates (see Figure 3) or remains (see Figure 2) a learner, and the learner becomes the educator (see Figures 2 and 3). This interplay between learner and educator demonstrates a move towards meddling rather than the traditional teacher-centered pedagogy. This is augmented by the educator who viewed their role as a "learner," "motivator/encourager," and "expert" (see Figure 2).

The lack of connection between learners and educators in the remaining three concept maps may indicate a gap in their integrated STEM knowledge, which can lead to a more teacher-centric view due to a lack of confidence in the content. In reviewing their open-ended responses, one indicated a segregated STEM view but was interested in finding "ways to become more of a STEM Teacher *[sic]*," one indicated they were not a STEM teacher, and the final educator indicated they viewed themselves as a STEM teacher who incorporates interdisciplinary teaching.

Discussion of Findings

This study builds upon prior research on PK-12 teachers' conceptions of STEM education (Dare et al., 2019; Holincheck & Galanti, 2022) and provides additional insight into how concept maps can be used as formative assessments to understand educators' conceptions of integrated STEM teaching and learning and their role within it. While previous research had educators rank STEM models for conceptual baselines (Dare et al., 2019) and used visual concept maps to elicit visual representations of educator conception of STEM (Holincheck & Galanti, 2022), this research extends previous work by additionally analyzing educators' view of their role as a part of STEM teaching and learning. The course instructor refined the prompt for the concept map assignment to provide space for teachers to explore their role in STEM teaching and learning and emphasize teachers' actions.

The data indicates that educators hold varied and, at times, multiple conceptions of STEM education and their roles as STEM educators. By allowing educators to layer ideas, illustrate connections, and incorporate their prior experience into their definitions, concept maps showed the educators' coordinating and conflicting conceptions of STEM education. Educators' responses to the question "Are you a STEM teacher?" further buttressed the use of concept maps as a lens to view educator conceptions of STEM education. Understanding educator conceptions of STEM education is useful for teacher educators, teacher preparation programs, and STEM education researchers.

Conclusions and Implications

Although a stated national priority, STEM education lacks a cohesive definition or framework (Bybee, 2018; Moore et al., 2020). In order to work together and collaborate across the field of STEM education, it is important to have shared definitions and terms (Dare et al., 2019). As the ones implementing STEM education initiatives, it is essential to elicit educators' conceptions. Capturing educators' views of STEM education and their roles as STEM educators allows teacher educators to focus their efforts on ways to build educator confidence in professional learning environments (Margot & Kettler, 2019). By allowing educators space to develop their definition of STEM education, teacher educators can better equip them with tools and resources to implement STEM initiatives in their community. Teacher educators should encourage the explicit development of STEM educator roles. It is incumbent upon teacher educators to recognize that each individual has a preconceived notion of STEM education and STEM educators' roles. Teacher educators play a key role in challenging problematic notions, particularly the widely held belief that STEM is inherently unbiased (Sheth, 2019). By helping educators understand their unconscious biases and encouraging discussions of racism and Whiteness within STEM education, teacher educators can disrupt the cycle of hegemonic racism and implicit biases present in education (Miller et al., 2023). Future research should explore using revised concept maps as continued formative assessments in professional learning settings.

Implications

Teacher educators can use formative assessments like the ones described in this paper to check for alignment with their own definitions and priorities in STEM education. Given that concept maps externalize a participant's internal thoughts and understandings of concepts, they can be used to initiate reflection. Reflection is essential for teacher educators to facilitate, as it encourages the growth of an educator's identity. Encouraging educators to assess if their practices align with their ideals (as seen in concept maps) allows them to confront inner discord and promote professional experimentation in alignment with their knowledge, beliefs, and attitudes (Clarke & Hollingsworth, 2002).

To adequately meet the needs of diverse students, educators' conceptualization of STEM education must include their understanding of how equity relates to how we imagine science, technology, engineering, and math (Le & Matias, 2019). As we encourage educators to integrate STEM disciplines into real-world contexts, educators must also be aware of STEM's intersectionality with contemporary (in)justices (Calabrese Barton & Tan, 2020). It is incumbent on teacher educators to elicit ideas about and provide a safe space for discomforting discussions about race and inequity in order to break racism's hegemonic stronghold in the classroom. In order to promote equity through STEM education, educators will need support in reflecting on the institutional anti-Blackness inherent in education and how students' lived experiences intersect with STEM content.

In order to implement STEM education initiatives, educators must navigate the multiple definitions of STEM education used by researchers, policy-makers, and their communities. The ambiguity surrounding STEM education leads to unclear expectations for educators (Dare et al., 2019). STEM education researchers can help alleviate this tension for educators by providing educators a voice in STEM education research. Appreciating educators' STEM education conceptions through concept maps allows researchers to see what topics are often linked by practitioners. This also provides researchers the unique ability to see commonalities across STEM education from the people who implement it.

Limitations

This study has a very small sample size, and it is not possible to generalize the findings to a larger population. Another constraint of this study is, due to the structure of the course, participants only made one version of the concept map with no encouragement to revise as they continued the course. Because of this, the participants' ability to make further connections within STEM teaching and learning cannot be analyzed. Further research could focus on encouraging participants to explain their concept maps, as there may be aspects of their STEM teaching and learning conceptions that participants may have deemed too insignificant or obvious to include on their official maps.

Pathways Forward

All too often, STEM education is defined by policymakers, researchers, or industry. In order to work together and collaborate, it is important to have shared definitions. As the ones implementing STEM education initiatives, it is essential to elicit educators' conceptions. A broad nationwide definition of STEM may hinder some integration initiatives; however, developing a common conceptual standard in a community may lead to more meaningful integration (Dare et al., 2019). Further research should be done on understanding educator conceptions of STEM education and using those to develop community-based conceptions of STEM education. Teacher educators are uniquely positioned to facilitate the creation of a collaborative definition of STEM education, and further research should be explored in this area. STEM education researchers should also be interested in furthering this work to understand educator interpretations of STEM education better. The open-ended nature of concept maps allows for authentic conceptualizations of STEM and provides a springboard for researchers to pinpoint trends and commonly held beliefs across STEM educators.

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Figures

Figure 1

Educator 1's Concept Map

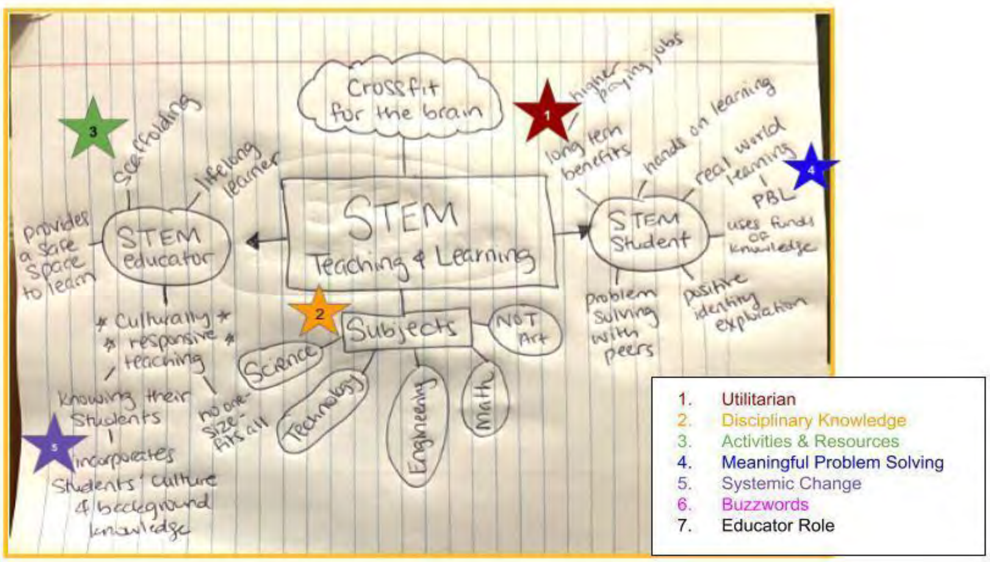


Figure 2

Educator 2's Concept Map

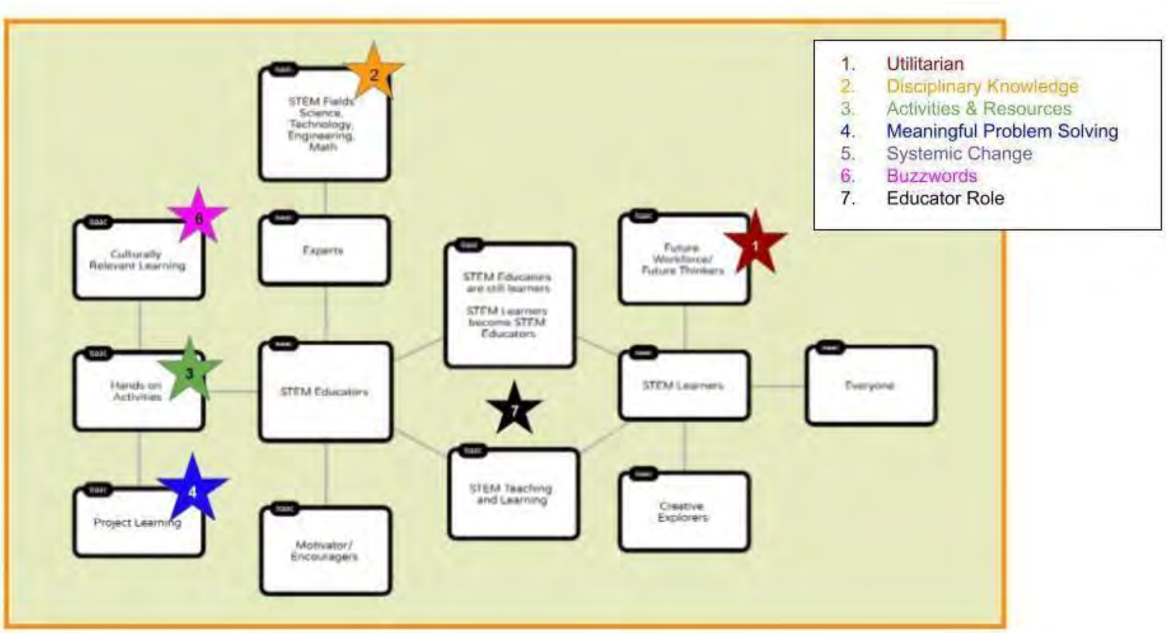


Figure 3

Educator 3's Concept Map

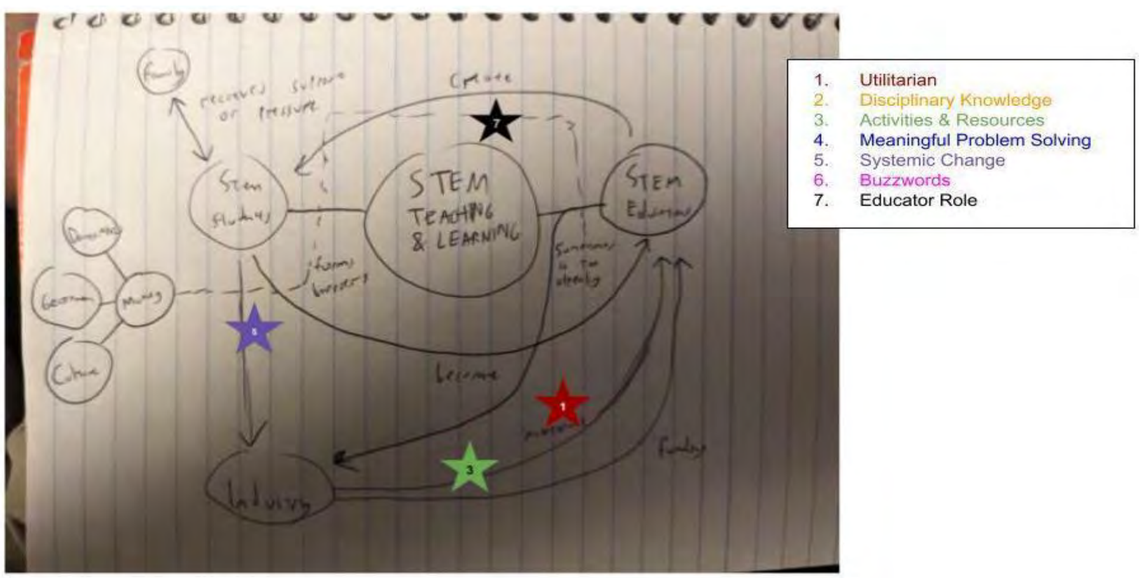


Figure 4

Educator 4's Concept Map

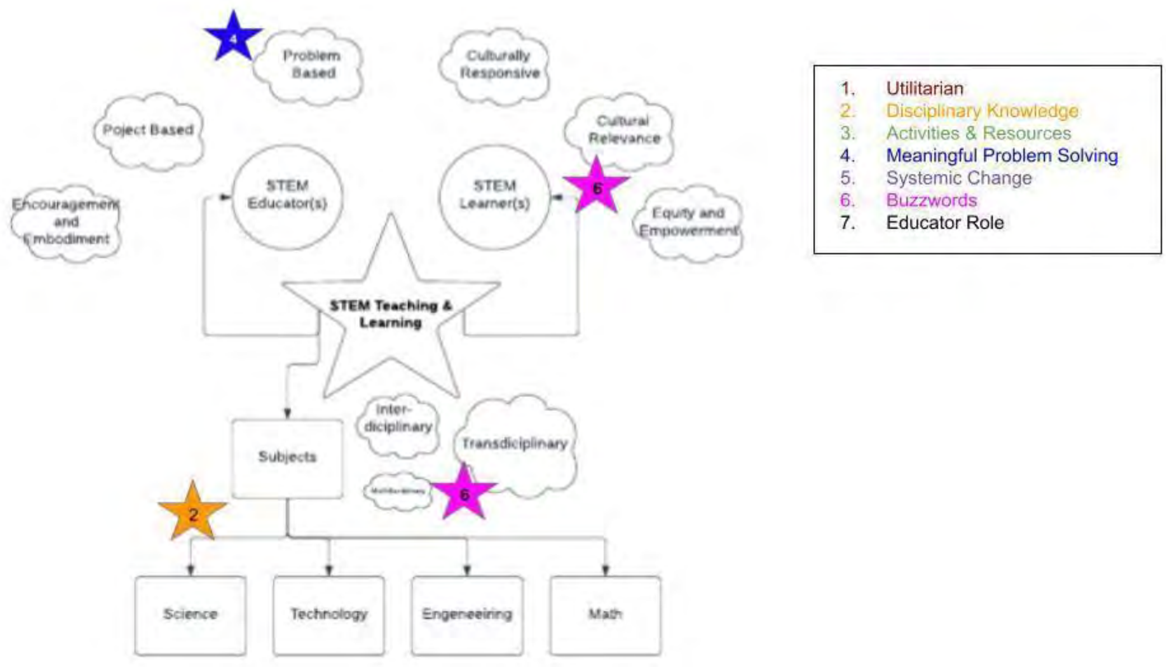

Problem Based
Culturally Responsive
Poject Based
Cultural Relevance
STEM Educator(s)
STEM Learner(s)
Encouragement and Embodiment
Equity and Empowerment
STEM Teaching & Learning
Inter-diciplinary
Transdiciplinary
Subjects
Science
Technology
Engeneeiring
Math
4
6
6
2
1. Utilitarian
2. Disciplinary Knowledge
3. Activities & Resources
4. Meaningful Problem Solving
5. Systemic Change
6. Buzzwords
7. Educator Role

Figure 5

Educator 5's Concept Map

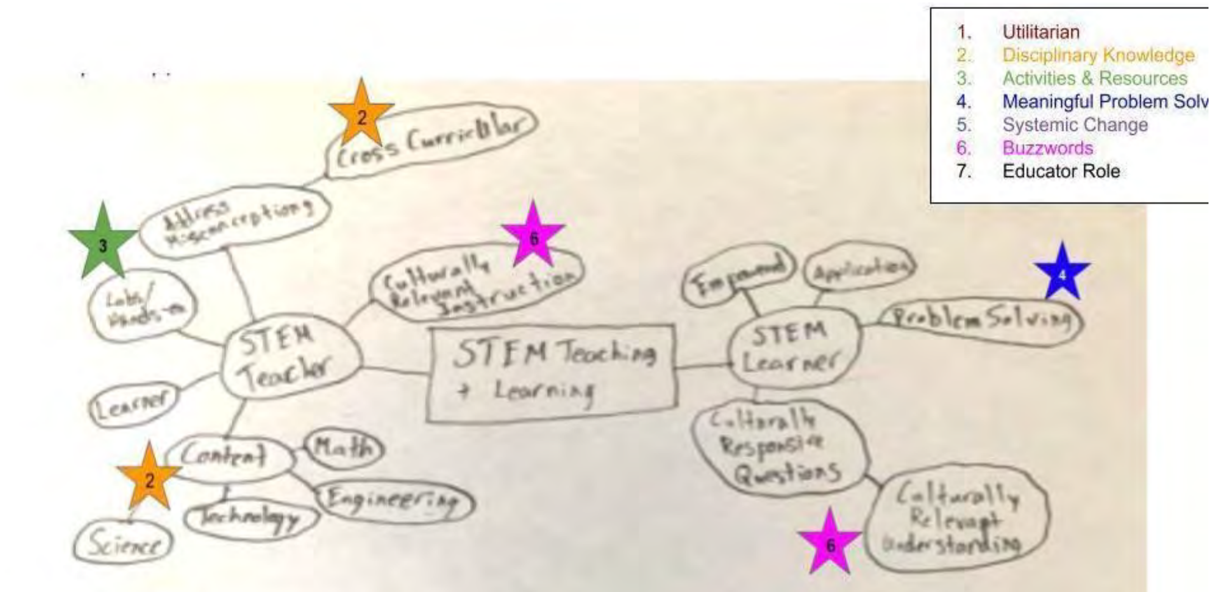
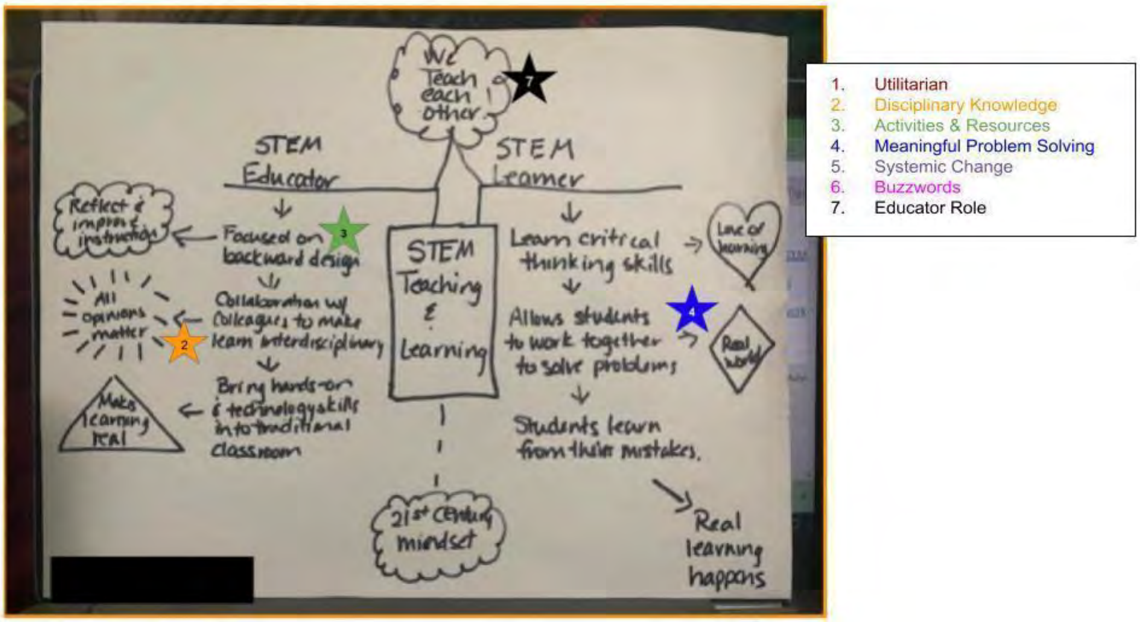


Figure 6

Educator 6's Concept Map


We Teach each other
STEM Educator
STEM Learner
Reflect & improve instruction
Focused on backward design
All opinions matter
Collaboration w/ colleagues to make learn interdisciplinary
Make learning real
Bring hands-on & technology skills into traditional classroom
STEM Teaching & Learning
Learn critical thinking skills
Love of learning
Allows students to work together to solve problems
Real world
Students learn from their mistakes.
Real learning happens
21st Century mindset
[redacted]
1. Utilitarian
2. Disciplinary Knowledge
3. Activities & Resources
4. Meaningful Problem Solving
5. Systemic Change
6. Buzzwords
7. Educator Role