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STEM SMART: Unpacking the Research on Teachers' Beliefs about Essential Life Skills and Dispositions

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ABSTRACT

Success in science and mathematics courses, and later in careers, requires more than disciplinary knowledge and general academic competencies. Students also need proficiency in certain key dispositions and life skills. This article is a systematic review of literature that examines what teachers believe about the non-academic skills necessary for student success in science, technology, engineering, and mathematics (STEM) classes and future careers in STEM fields. We report our results of the literature review and discuss these in terms of *STEM SMART skills* – non-academic skills and dispositions that support students' learning across science and mathematics. These life skills and dispositions are usually not studied as academic skills; nevertheless, they are essential for long-term success in STEM fields. The acronym *STEM SMART* is intended to serve as a mnemonic to help educators and others remember and discuss these life skills and dispositions that support STEM learning.

Keywords: teacher beliefs, STEM education, life skills, learner dispositions, STEM SMART, systematic literature review

Introduction

Classroom teachers understand much more about their students than academic performance. Within the classroom context, teachers observe many non-academic aspects of students' dispositions and character traits. Educational research has long shown that teacher beliefs about students can influence student performance (Hamre & Pianta, 2001; McKown & Weinstein, 2008; Rosenthal & Jacobson, 1968). Most studies about teacher beliefs focus on how teacher beliefs affect teacher behavior toward students or instructional innovation (Bryan, 2012; Brophy & Good, 1986; Wang, Haertel, Walberg, 1993). Similarly, the *Next Generation of Science Standards* (NGSS, 2013), the *Common*

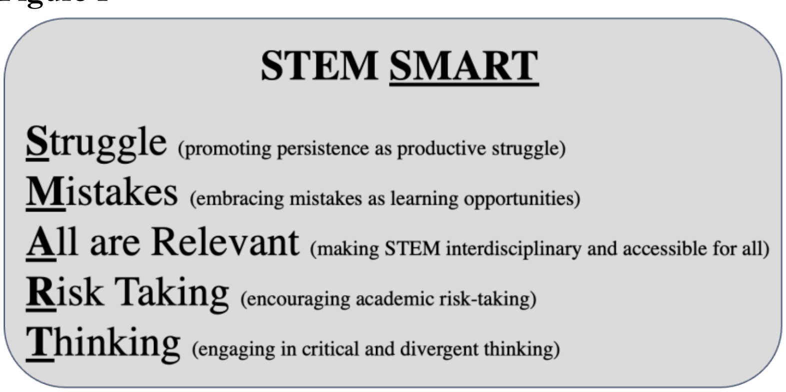
Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), and the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) focus on practices and skills to specifically promote student academic achievement in the STEM area.

After conducting workshops and family engagement events with science and mathematics teachers over the course of several years (Hoffman, Suh, & Zollman., 2021; Zollman, Hoffman, & Suh, in press), we have heard many classroom teachers discuss their beliefs about the importance of specific life skills required for student success in Science, Technology, Engineering, and Mathematics (STEM) coursework. These conversations with teachers led us to question which non-academic skills teachers see as particularly relevant for student success in STEM courses. For years, teachers have been talking about these skills in general ways, often using terms from outside the education field such as "soft skills" (Berdanier, 2022) or "21st century skills" (Ng, 2019).

Rather than focusing on what teachers believe about students and their achievement, however, this study focuses on teacher beliefs about a particular set of skills. Specifically, we sought to pinpoint what life skills and non-academic character traits teachers believe lead to success in STEM fields in order to help teachers unpack and apply the research behind the body of nonacademic skills students need to be successful. This is not an exhaustive search of the literature on all life skills that support STEM, but instead an analysis of how teachers' perceptions of these needed skills and their efforts to support these skills are discussed in the literature. Because we value teachers' experience, observations, insights, and knowledge about what non-academic skills correlate with students' learning and performance, we grounded our research on teacher beliefs about this aspect of student development. The present study was guided by the following research questions: How are teacher beliefs about life skills relevant to STEM learning characterized in the literature? And what recommendations do teachers make to support the development of these skills?

In this article, we report on the examination of the research and ultimately present an acronym, STEM SMART, which we intend to serve as a mnemonic to help educators and others remember and foster the life skills and dispositions that support STEM learning (Hoffman et al., 2021; Figure 1). Based on the major discrete skill categories which emerged from our analysis of the published research, the acronym refers to S for struggle (promoting persistence as productive struggle), M for mistakes (embracing mistakes as learning opportunities), A for STEM's relevance for all people (making STEM interdisciplinary and accessible for all), R for risk taking (encouraging academic risk taking), and T for critical and divergent thinking (supporting critical thinking). It is our hope that this acronym not only succinctly presents the existing literature but, more importantly, helps teachers unpack and apply the research on teacher beliefs about the nonacademic life skills students must develop to be successful in their STEM classes and beyond.

Figure 1



Guiding Literature

Given the fast pace of innovation in STEM careers, educators and industry experts emphasize the importance of individuals' adaptability and soft skills development for long term STEM success (Schulz, 2008; Wats & Wats, 2009; White, 2020). For many years, researchers across many fields have studied the role of non-academic skills in academic success and career readiness. These human-focused competencies (Berdanier, 2021) have been called life skills, soft skills, twenty-first century skills, transversal skills, and nontechnical skills (Succi & Canovi, 2020). Such skills have been cited as critical to graduates' employability (Claxton et al., 2016) and have even been added as required student outcomes for engineering programs by the Accreditation Board of Engineering and Technology (ABET, 2016; Hirudayaraj et al., 2021). Still, scholars have not come to a consensus on a list of skills needed for employability (Griffiths, Brady, Riley, Alsip, Trine, & Gomez, 2018). In recent years, some scholars have advocated for retiring the term "soft skills" (Berdanier, 2021; Parlamis & Monnot, 2019), in part because choices in terminology can connote certain domains or skills being less professional and therefore less important than "hard" or technical skills.

In business, soft skills often refer to interpersonal skills that characterize a person's relationships with other people. In the workplace, soft skills are a complement to hard skills, which refer to a person's knowledge and occupational skills. Soft skills have more to do with how people operate rather than what they know. As such, they encompass the character traits that decide how well one interacts with others (Majid, Liming, Tong, & Raihana, 2012). In the business world, employees acquire hard skills through formal education or training programs. Hard skills can be learned and perfected over time, but soft skills are more difficult to acquire and change (Mitchell, Skinner, & White, 2010). Some in education use the term soft skills to describe a person's social/emotional intellectual skills as opposed to knowledge/intellectual skills (Cohen & Sandy, 2007; Kenton, 2021; Scheerens, van der Werf, & de Boer, 2020). Given these differences in meaning across disciplines, we suggest the term "soft skills" is not an accurate description of the skills educators want to foster in their students. The term "21st century skills" is also problematic, as it is not clearly defined and seems a curious choice for current students who were born into the 21st century. Instead, we introduce the term "STEM SMART skills" to describe the necessary skill set which emerged from our systematic review of the literature.

Methodology

Systematic reviews of the literature apply detailed, comprehensive analysis to identify, appraise, and synthesize studies and reduce bias (Davis, Mengersen, Bennett, & Mazerolle, 2014; Denyer & Tranfield, 2009; Uman, 2011). Systematic reviews can communicate the current state of research, determine themes across studies, and guide future investigations. The purpose of this systematic review was to collect and analyze the current research conducted on teachers' beliefs about student nonacademic skills necessary for students' success in the STEM area.

Data Collection

This study was conducted using a university library database supplemented by Google Scholar to search for the keywords "teachers," "beliefs," "STEM," "student," and "success" in a ten-year range from 2011 to 2021. Our inclusion criteria were peer-reviewed articles addressing teachers' beliefs and perceptions about students' life skills to succeed in STEM. We included articles from different countries and a range of levels from kindergarten to college and graduate school. Google Scholar was used to supplement this review of the literature because is the largest database of educational research.

It also overlaps with most other large educational databases. Our first search yielded about 20,200 results. From this initial result, the first fifteen pages (150 items) were manually reviewed to select peer-reviewed articles matching our search criteria. Thus, articles that lacked one of the key terms within the summary or the paper were eliminated. For instance, a paper by De Angelis (2011) on teachers' beliefs about the role of prior language knowledge lacked discussion of STEM topics and, therefore, was discarded. To increase the sample size and relevance of included articles, other papers that used synonyms of our key words were added. For example, Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester's, (2013) "Teacher STEM Perception and Preparation: Inquiry-Based STEM Professional Development for Elementary Teachers" used the word "perceptions" instead of "beliefs" and was added to the article corpus.

After eliminating articles outside of our search criteria, we obtained twenty-four articles that fulfilled our research criteria and were included in this literature review. The articles were first read to identify the focus and were subsequently categorized as: "Teacher Practices," "Literature Review" "Teacher Beliefs about Student Backgrounds" and "Learning Outcomes." An individual article could be identified as falling within multiple categories. For example, Chrysostomou and Philippou's (2010) article "Teachers' Epistemological Beliefs and Efficacy Beliefs about Mathematics" was coded as both "Teacher Practices" and "Teacher Beliefs about Student Backgrounds." Seventeen articles were identified as "Teacher Practices," one article was classified as "Literature Review," five articles discussed "Teacher Beliefs about Student Backgrounds," and one paper was classified as "Learning Outcomes" (Appendix).

Data Analysis

Articles matching the focus of the literature review were analyzed qualitatively to identify common themes across the literature related to what is currently known about STEM teachers' beliefs about the dispositions necessary for students' STEM learning. The authors applied thematic analysis (Braun & Clarke, 2012), which is a rigorous qualitative method involving the establishment of analytic categories and their provisional definitions in six phases: (a) familiarization through multiple readings of the data; (b) formulation of initial codes by identifying common themes and novel trends; (c) search for themes by reviewing coded segments and generalizability to a larger section of the data; (d) review potential themes by comparing across coded segments; (e) definition and naming of themes; and (f) establishing theme boundaries.

After multiple reads of the corpus to familiarize ourselves with the data, we began identifying common themes and trends across articles which allowed us to create our initial codes. For example, several articles mentioned the importance of teaching STEM in and for a variety of contexts, which we initially identified as part of the emerging theme "Multiple Contexts." We then identified this theme within several texts, noting the appropriate coded segment with MaxQDA, a qualitative data analysis software. The first author developed the initial codebook and was joined by the research team in applying the codebook in our subsequent analysis. After our initial coding of the data, we confirmed the code categories by assessing generalizable relationships and connections between coded segments within a code category.

We also sought to identify broader themes by identifying connections between different code categories. For instance, coded segments from the emerging theme "Multiple Contexts" were combined with another emerging theme "Social/Cultural Contexts of STEM" to form a broader theme which was later named "All Types of STEM" (the letter A in the SMART acronym. Once each coded segment within this theme was reviewed, the theme was defined as STEM contexts beyond traditional or theoretical applications. The theme boundaries were established to include school-based and extracurricular applications of STEM, including social and cultural contexts for STEM learning at school. However, the theme boundaries excluded STEM learning that occurred outside of school.

Instead, these outside-of-school based STEM references became part of the theme "All Types of Learning Environments." Both "All Types of STEM" and "All Types of Learning Environments" became child codes within the larger theme of "Making STEM Accessible for All" and "Viewing STEM as Interdisciplinary."

After defining and naming the themes, we calculated the number of utterances (or times the theme was referenced in the literature) and selected a quote from the literature to represent that particular belief about necessary dispositions. In our calculations of the count data, a single phrase could be counted multiple times if it related to multiple codes. For example, "All three teachers...believe that problem solving plays an important role in integrating engineering into science and mathematics" (Wang, Moore, Roehrig, & Park, 2011, p. 10) was coded as both "STEM for All" and "Promoting Persistence." In this way, this single quote yielded two instances to be coded.

Findings

The analysis yielded six overarching themes related to teachers' beliefs about necessary dispositions for STEM learning. We used such themes to build the SMART acronym, **S** is for struggle (promoting persistence as productive struggle), **M** is for mistakes (embracing mistakes as learning opportunities), **A** is for STEM's relevance for all people (making STEM interdisciplinary and accessible for all), **R** is for risk taking (encouraging academic risk taking), and **T** is for critical and divergent thinking (supporting critical thinking). Below we present qualitative and frequency count data from each of the emerging themes.

Promoting Persistence through Productive Struggle

Persistence was also an important skill that teachers identified for success in STEM (35 instances). Most frequently, teachers and teacher educators referred to persistence in reference to a mindset that was open to challenges and the benefits of productive struggle." Such theme represented the letter S in the SMART acronym because of the used of the struggle to foster students' persistence. The literature also reported the importance of setting high expectations for students, for instance, a teacher who continuously pushed her students to struggle in the classroom while solving STEM-related problems (Dare, Ellis, & Roehrig, 2014). The teacher claimed that the more students face problems, the more they get used to them and enhance their learning in problem-solving. Such a mentality is related to improving persistence as the teacher used productive struggle to increase her students' perseverance while solving problems. Table 1 summarizes the three dominant themes related to persistence.

Table 1

Examples of Persistence Themes from the Literature

Subtheme	Example Quote
"Mindset" (15)	"[Teachers] seemed to hold more growth mindsets, agreeing that hard work and effort could lead to success in mathematics" (Copur-Gencturk et al., 2020, p. 1264)
"Communicating High Expectations" (10)	"When teachers had high expectations for students, however, these students typically met the higher expectations of performance" (Nathan et al., 2010, p. 410)
"Productive Struggle"	"Effective schools have been found to embrace and promote a strong common

(10)	mission and vision, fostered by focused school leaders, that articulates high expectations for minority student success" (Dare et al., 2014, p. 10)

"Mindset" emerged as the dominant subtheme with 15 examples in the data. This subtheme referred to taking advantage of learners' enthusiasm, intrinsic and extrinsic motivations, interests, positive attitudes, and self-regulation to explore STEM concepts. Also, the subtheme of mindset was related to teachers who believed that mentality can be modeled and nurtured. Many teachers agreed that students that showed hard work and effort could succeed in STEM areas. For instance, Copur-Gencturk, Cimpian, Lubienski, & Thacker (2020) showed their results after studying teachers' beliefs about students' mathematical aptitudes. They found that the teachers in their sample had growth mindsets. This way of thinking means that the teachers believe students can modify their mindset through hard work and effort. This type of belief is related to the mindset subtheme because it shows a conviction in which the students' mentality can be sculpted and developed.

Encouraging Academic Risk Taking

In the literature, "Academic Risk Taking," which represents the letter R in the SMART acronym, was the most frequently referenced skill (60 instances) in relation to students' success in STEM. Overall, risk taking in the literature included encouraging students to become self-directed and to solve problems through inquiry. Teachers also believed that it was important to encourage cooperative and intrinsically motivated learning. For example, Van Haneghan, Pruet, Neal-Waltman, & Harlan (2015) found that teachers believe students must develop the skills to analyze, interpret data, identify, formulate, solve problems, and become self-directed learners. This belief about necessary skills for students to learn STEM-related topics is under the umbrella of risk-taking because it contains ideas or beliefs of students becoming self-directed and solving problems. Another example was found in Stohlmann, Moore, & Roehrig (2012) which included the results of a model for teaching integrated STEM education. They found that the teachers involved in the research believed in the importance of having students work together and develop their ideas. This teaching style is related to the view of risk-taking as an essential factor in encouraging cooperative and intrinsically motivated learning.

Table 2

Examples of Encouraging Academic Risk Taking in the Literature

Subtheme	Example Quote
"Give Time and Space" (37)	"His view that scientific inquiry in the classroom can occur only if the students are fully in charge of designing and implementing an investigation" (Park Rogers et al., 2010, p. 906)
"Encourage Questioning" (14)	"The purpose of the motivating and engaging context provides students with real problems that require them to draw from multiple disciplines in order to solve a given problem or challenge" (Dare et al., 2014, p. 2)
"Support Wonder" (9)	"Opportunities include capitalizing on the enthusiasm of young learners and their desire to explore STEM concepts, the development of student foundational STEM knowledge, and flexibility in the elementary curriculum that can more readily support innovative approaches for teaching STEM content" (Nadelson et al., 2013, p. 157)

The overall theme of Academic Risk Taking encompassed three subthemes (Table 2). Within the larger theme of "Academic Risk-Taking," the most frequently occurring subtheme was "Give Time and Space." This subtheme referred to giving students the freedom to explore, think creatively, identify and formulate problems, design their work, and allow the development of independent learning. Additionally, it conveyed respect for each student's learning process and gave numerous opportunities to learn, such as demonstrated by Park Rogers, Cross, Gresalfi, Trauth-Nare, & Buck (2010; Table 2). The researchers described a teacher's belief that "scientific inquiry in the classroom can occur only if the students are fully in charge of designing and implementing an investigation" (Park Rogers et al., 2010, p. 906). Such a view demonstrates the subtheme of giving time and space by acknowledging that students need space to be in control of their learning.

Making STEM Accessible for All and Viewing STEM as Interdisciplinary

We conceptualized the theme "STEM for All and All Things as STEM" (44 instances) as emphasizing the interdisciplinary nature of STEM as learning that can occur in multiple environments and can be accessible for every learner. Such theme represents the letter A in the SMART acronym. An example of the code "STEM for all" in the literature is when Nathan, Tran, Atwood, Prevost, & Phelps (2010) cited Lewis' (2007) calling to expand engineering education accessibility for all students. Nathan et al. describe the tension in teacher beliefs between those who view K-12 engineering as a pathway to postsecondary engineering studies and those who believe all students benefit from engineering education to support their technological literacy. The theme also related to our growing understanding of STEM as including the social and cultural contexts of school-based and extracurricular applications of STEM. Nathan et al., 2010 , for example, found that teachers believe engineering preparation occurs in multiple contexts, including students' homes and communities as well as school and workplace settings. While these examples come particularly from engineering education studies, overall, this theme included explicit references to interdisciplinarity more than to the discrete disciplines of science, technology, engineering, or mathematics (Table 3).

Table 3

Examples of STEM for All and All Things as STEM in the Literature

Subtheme	**Example Quote**
"All Types of STEM (Integrated Disciplines)" (25)	"All three teachers believed that science, mathematics, and engineering are related in a very natural way, either by content or problem solving processes" (Wang et al., 2011, p. 10)
"All Types of Students" (16)	"[Teachers held the epistemological belief that] If a student is *not* naturally gifted in mathematics, they can still learn the class materials well" (Chrysostomou & Philippou, 2010, p. 1512)
"All Types of Learning Environments" (3)	"Connection between in-school and out-of-school learning" (Nathan et al., 2010, p. 14)

With 25 instances in the corpus, the most frequent subtheme, "All Types of STEM", referred not just to the integration of science, technology, engineering, and mathematics but also to non-traditional or applied instructional foci. For example, Dare and colleagues (2014) cited Moore, Stohlmann, Wang, Tank, Glancy, & Roehrig's (2014) claim that the purpose of engaging instructional contexts is to provide students with real problems that require knowledge from multiple disciplines to solve. This theme emphasized teachers' beliefs about the importance of students' understanding of STEM as relevant to all people and in all areas of life. The theme illuminated teachers' beliefs that students can increase their interest in STEM through a range of experiences. It also supports STEM learning's relevance to other types of learning and all learners. Although not explicitly stated within any of the reviewed articles, we conceptualized the relevant life skill teachers referenced within this theme as students' awareness of and openness to STEM as a connective force to the world around them.

Embracing Mistakes as Problem Solving Opportunities

The literature contained several references to how STEM teachers believed mistakes should be seen as opportunities to learn (Table 4; 44 instances). Such code represents the letter M in the SMART acronym. Teachers were most likely to emphasize the complexity of problems and students' self-image as problem-solvers (Table 3). For instance, in their case study of middle school teachers integrating STEM across multiple disciplines, Wang and collaborators (2011) noted how teachers "believe that STEM integration helps their students to not be afraid to make mistakes and to think that they are able to accomplish something they could not do before" (p. 11).

The emphasis on embracing mistakes was a key finding from Wang et al. (2011) and alluded to another core aspect of problem solving as an integral part of the value of making mistakes. This mindset also reinforced students' views of themselves as problem solvers–a key aspect of their willingness to make mistakes. An example of this was reported by Dare et al. (2014), whose literature review discussed providing students with real problems that require using knowledge from multiple disciplines to find a solution as a way to help students engage in the class context. This way of thinking of thinking is related to the idea that complex problems require complex solutions and that mistakes are a natural part of seeking such solutions.

Table 4

Examples of Encouraging Mistakes as Problem Solving Opportunities from the Literature

Subtheme	Example Quote
"Complex Problems have Complex Solutions" (21)	"There isn't always one right answer. You know, there's lots of different ways you can approach a problem and there's lots of different results you can get. In a way that's kind of how the real world goes" (Dare et al., 2014, p. 7)
"Promoting Positive Self-Image as Problem-Solvers" (20)	"She believed STEM integration helped her students to think independently and to become more confident in learning, to learn how to communicate with each other, and to become skilled at teamwork" (Wang et al., 2011, p. 10)
"Avoiding Perfectionism" (3)	"James was careful in talking about his students' hesitation to begin work with the wind turbines, almost being afraid to touch the equipment because they were afraid that they would do something wrong" (Dare et al., 2014, p. 10)

The most frequently occurring subtheme under the theme of "Embracing Mistakes as Learning" moments was "Complex Problems have Complex Solutions." This belief reflected the importance of helping students think creatively, work collectively, and use interdisciplinary knowledge. It also includes the idea that a problem can be approached in different ways. For instance, Dare et al. (2014) described a teacher who thought that the best way to teach students was by giving them problems with multiple correct answers. The teacher said, "There's lots of different ways you can approach a problem and there's lots of different results you can get" (Dare et al., 2014, p. 7). Such a mindset illustrates the subtheme of "Complex Problems have Complex Solutions" by acknowledging that real world situations do not always have only one correct answer and that creative thinking is a necessary life skill for approaching complex problems.

Supporting Critical Thinking

"Supporting Critical Thinking" was the final theme we uncovered with 11 instances. Although the theme was numerically less substantial than the other thematic categories, the theme's representation in eight different articles indicates its significance in discussions of teacher beliefs about life skills and dispositions essential to STEM learning. STEM educators and professionals typically define critical thinking as an important application of the scientific method to formulate and solve problems using inquisitiveness and multidisciplinary knowledge. This involves encouraging students to think outside of the box and learn through their own experiences to become self-directed learners. The corpus contained both these subthemes, with explicit references to critical thinking being more common (Table 5). For instance, Radloff and Guzey (2016) found that preservice teachers believed that creative and critical thinking were essential for student success in STEM areas. The subtheme "Thinking Outside of the Box" also included the importance of creativity, such as Chriostomou and Philippou's (2010) factor analysis of teachers' epistemological beliefs of mathematics in which the authors described the importance of teachers' belief that "doing mathematics involves exploration and creativity" (p. 1512).

Table 5

Examples of Supporting Critical Thinking Themes from the Literature

Subtheme	**Example Quote**
"Critical Thinking" (8)	"[Preservice Teachers' instructional conceptions included] real-world application and context, creative and critical thinking, discovery or hands-on learning" (Radloff & Guzey, 2016, p. 766)
"Thinking Outside of the Box" (3)	"His goal as a teacher is to make a difference in the world through teaching, challenging students to think outside-the-box and not always give them the answer right away" (Dare et al., 2014, p. 7)

Building Skills for the Future

A final theme, which was not directly accounted for in our original SMART acronym related to skills for the future. The literature also included 27 references to "Building Skills for the Future" to prepare students for success beyond high school and in their future as productive citizens and workers (Table 5). Such skills included citizen and ethical behaviors, technological skills, interdisciplinary knowledge connected to the real world, and communication skills. For instance, O'Neal, Gibson, Cotten, (2017) summarized the beliefs of a teacher who argued that students need to develop technical skills such as the skill to communicate online. The teacher claimed that this type of communication is becoming an essential component of our modern society. As these examples show, such skills are not traditionally or explicitly taught. However, there is a growing interest in technological skills-in STEM disciplines. Another essential skill mentioned was problem-solving related to real-world contexts.

Teachers specify that students must have the skills to find socio-scientific connections while making decisions and problem solving. In other words, students should consider a technological or scientific issue's economic, social, ethical, geographical, cultural, historical, and political context.

Table 6 includes the three most dominant themes for "Skills for the Future." The need to define non-academic life skills more specifically is, in fact, a major reason for undertaking our research. We report on teacher discussions of these "Skills for the Future" as a discrete set of findings as this theme have historically appeared in the literature within the context of "21st Century Skills." However, the term "21st Century Skills" is difficult to define. As such, some readers will see a connection between these skills and the other skills discussed in our STEM SMART framework. We sought to distinguish the other skills as explicitly connecting to our framework.

Table 6

Examples of Skills for the Future

Subtheme	Example Quote
"Seeing Real World Applications" (10)	"Student should… focus on the [hypothetical] client (the one who would keep the chair) to find answers to their questions" (Wang et al., 2011, p. 9)
"Making Connections to the Broader World" (8)	"Give students more meaningful learning experiences by connecting disciplinary knowledge with personal and real world experiences" (Wang et al., 2011, p. 3)
"Understanding Problems in New Ways" (6)	"Students can function effectively as a part of a multidisciplinary team" (Van Haneghan et al., 2015, p. 2)

Conclusions, Limitations, and Implications

In exploring the implications of this systematic review of the literature, we begin by addressing the study's limitations and delimitations.

Delimitations and Limitations

A possible limitation of our study is that we limited our work to research in a university library database supplemented with a Google Scholar search without cross referencing the articles in our corpus with other databases such as EBSCOhost. As noted in our methods, our choice to use Google Scholar was an intentional delimit of the research design. Our study's delimitations were informed by conversations with STEM teachers during which they discussed the non-academic life skills students needed in addition to the curriculum they were teaching. As such, we focused on analysis on non-academic and non-discipline specific skills.

Although previous research indicates that teacher beliefs are important and connect to classroom practice in meaningful ways, there are several limitations and challenges in identifying teachers' beliefs and attitudes. First, there is the limitation involved in all data analyses drawing from data which include only a single instance of the central phenomenon. For instance, some authors mentioned teacher beliefs only one time in an article, thereby limiting the depth of their discussion of those beliefs. Because so few studies focus explicitly on teacher beliefs about non-academic life skills, we included even these single mentions in order to expand our corpus. Another limitation of this study is that we focused on teachers' beliefs and perceptions rather than on what investigations have shown are the essential life skills to reach success in the STEM area. Therefore, further, correlations are not evidence of causation. A teacher's infusion of these skills in their teaching does not automatically result in student learning. The process of learning is a complicated undertaking, involving a multitude of factors. Simply put, these life skills and dispositions, in teachers' opinions, are necessary but not sufficient for student success in STEM education. Future research should explore how teachers make sense of the STEM SMART acronym for conceptualizing the life skills necessary for succeeding in STEM and beyond. Additional research can explore the impact of various interventions addressing a particular aspect of the STEM SMART framework.

Implications

Although there are many studies about the relevance of "soft skills" or "21st century skills" to STEM learning, this review of the literature is delimited to teachers' perceptions of which skills and dispositions benefit students across STEM disciplines or for the purpose of developing a STEM disposition. This literature review identified these six major themes, summarized here in descending order of frequency as encouraging academic risk taking; making STEM accessible for all and viewing STEM as interdisciplinary; embracing mistakes as problem-solving opportunities; building non-academic life skills; promoting persistence as productive struggle; and supporting critical thinking.

Of the six themes uncovered in the literature review, five refer to life skills and dispositions that teachers believe students need to master to be successful in STEM classes. One of the themes, Building Life Skills for the Future, is not its own set of skills but rather encompasses a broad array of life skills and dispositions learned outside of formal curriculum (such as those encompassed by the terms soft skills and 21st century skills, as discussed previously.). In order to aid further discussion of these important topics, we reworked the categories of skills and dispositions into an acronym, STEM SMART. The acronym is intended to serve as a mnemonic to help educators and others remember and discuss these life skills and dispositions that support STEM learning (Hoffman et al., 2021). Using the SMART acronym, **S** is for struggle (promoting persistence as productive struggle), **M** is for mistakes (embracing mistakes as learning opportunities), **A** is for STEM's relevance for all people (making STEM interdisciplinary and accessible for all), **R** is for risk taking (encouraging academic risk taking), and **T** is for critical and divergent thinking (supporting critical thinking).

STEM SMART skills include "commonsense" life skills, separate from explicit content skills and knowledge, that are typically not taught explicitly in schools. Yet our literature review demonstrates that teachers believe these skills and dispositions to be instrumental in students' success in STEM disciplines. We know from prior research that teachers' beliefs often directly affect their actions and therefore are an important influence on student learning outcomes (Fenstermacher, 1994; Richardson, 1994). Teachers support of STEM SMART skills aligns with Darling-Hammond and Cook-Harvey's (2018) research brief on educating the whole child; this work focuses on developing students' wellbeing in academic, cognitive, social-emotional, physical, mental, and self-identity contexts. In particular, STEM SMART skills and dispositions target self-identity and social-emotional development in ways not always addressed in school (Hoffman et al., 2021; Suh et al., 2022). For all these reasons, we encourage teacher educators to address and discuss these life skills and dispositions explicitly when discussing STEM learning.

To teacher educators, our research is not implying that teacher educators teach STEM SMART skills as part of a separate curriculum. Rather, teachers can model and emphasize the value of STEM SMART skills and dispositions across the existing academic curriculum. By normalizing STEM SMART skills, teachers strengthen students' abilities to see STEM all around them and to see themselves as being successful in the STEM classroom – and beyond.

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Appendix

Review of Literature

	Author Last Name (Year)	*Discipline*	*Grade Level*	*Teacher Practices*	*Literature Review*	*Teachers' Beliefs on Students' Background*	*Learning Outcomes*
1	Archambault et al. (2012)	Mathematics	Secondary	X			
2	Barak (2014)	STEM	Pre-Service Teachers	X			
3	Blanchard et al. (2016)	Technology	Middle School	X			
4	Chrysostomou & Philippou (2010)	Mathematics	Primary School	X		X	
5	Copur-Gencturk et al. (2019)	Mathematics	K-8			X	
6	Dare et al. (2014)	Engineering & Physics	K-12	X		X	
7	Ebert-May et al. (2015)	STEM	College/ Graduate	X			
8	Edmondson (2019)	STEM	High School			X	
9	Lazarides & Watt (2015)	Mathematics	Grade 10			X	
10	Margot & Kettler (2019)	STEM	K-12		X	X	

11	Miranda & Russell (2012)	Technology	Elementary	X			
12	Nadelson et al. (2013)	STEM	Elementary	X			
13	Nathan et al. (2010)	Engineering	High School	X		X	
14	O' Neal et al. (2017)	Technology	K-12			X	
15	Park et al. (2017)	STEM	Early Childhood	X		X	
16	Park Rogers et al. (2011)	Mathematics & Science	K-12	X			
17	Pizdrowski et al. (2012)	Mathematics	High School	X		X	
18	Pryor et al. (2016)	STEM	Elementary, Middle, and High School	X			
19	Radloff & Guzey (2016)	STEM	College	X			
20	Smith et al, (2015)	STEM	Secondary	X			
21	Stohlmann et al. (2012)	STEM	Middle School	X			
22	Tofel-Grelh & Callahan (2017)	STEM	High School			X	
23	Van Haneghan et al. (215)	Engineering	Middle School				X
24	Wang et al. (2011)	STEM	Middle School	X			