SUPPORTING MOTIVATION FOR STEM IN RURAL CONTEXTS: A SYSTEMATIC REVIEW

by

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(Under the Direction of Michael Barger)

ABSTRACT

Rural students remain underrepresented in STEM fields even as the number of STEM education initiatives and the demand for workers in STEM disciplines rises. Due to the centrality of motivation in task initiation and persistence, this study utilized a systematic review process to better understand the multifaceted ways in which motivation has been studied within rural contexts to support rural students in STEM. Despite negative perceptions of rural education, several strategies for supporting student motivation were found to already exist within rural STEM classrooms. These include promoting student engagement through partnerships, fostering identity and belonging through culturally relevant and place-based pedagogy, and building teacher competency through curriculum training. However, limitations in how and what motivation has been studied and the ways in which motivational supports have been applied reduce the generalization of these findings across diverse rural contexts and highlight the need for exploration of new avenues of motivational research.

INDEX WORDS: rural, motivation, STEM

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Introduction

Education in science, technology, engineering, and mathematics (STEM) disciplines remains a focus for educators across the United States as the demand for diverse workers in STEM fields continues to rise (ACT, 2017). To meet these demands, an influx of educational initiatives designed to promote increased exposure to STEM curriculum and adequate preparation to pursue STEM fields have been created (DeJarnette, 2012). However, geographic disparities in the success of these initiatives exist. Specifically, students from rural areas continue to have fewer advanced course offerings in STEM (Irvin et al., 2017), less STEM learning opportunities both within and outside of school (Chan et al., 2020; Saw et al., 2019), and lower enrollment in post-secondary STEM majors (Saw & Agger, 2021). These disparities are often further compounded for students from rural areas with intersecting identities which are underrepresented within STEM, namely women and Students of Color. As such, research designed to specifically understand how to support rural students in pursuing STEM fields represents a potential solution to addressing the shortage of diverse STEM workers nationwide.

When considering this geographic disparity, literature often focuses on the educational barriers or challenges which prevent rural students from entering STEM fields. These barriers include increased isolation, high teacher turnover, lack of qualified teachers, limited access to resources, few local role models, and minimal consideration of the diverse backgrounds of rural students (Avery, 2013; Barley, 2009; Harris & Hodges, 2018; Showalter et al., 2019; & Whannell & Tobias, 2015). These challenges are often viewed as deficits and have been known to contribute to the stereotype of rural students as both uneducated and unmotivated to learn (Azano & Stewart, 2015; Azano, Bass, & Wright 2021; Theobald & Wood, 2010). Furthermore, these stereotypes run counter to the notions of intelligence and academic persistence often thought to be necessary for success in STEM fields (Bian, Leslie, & Cimpian, 2017; Napp & Breda, 2022). Yet to discount rural students within the field of STEM would be to eliminate the contributions of nearly one-fifth of all school aged children in the United States from this field (Showalter et. al, 2019). Likewise, each of these barriers can be addressed if given the proper supports. However, the geographic gap in STEM representation, opportunities, and preparedness cannot be fully understood by simply determining the number of barriers to STEM education in rural communities and implementing solutions to address them. It is also necessary to study the ways in which educational practices and policies influence rural students' and teachers' motivation for STEM learning and teaching respectively.

The Role of Motivation

The development of student motivation for STEM is foundational to life-long learning in this field (Bell et al., 2009; Hossain & Robinson, 2012). Motivation concerns the willingness for engaging a particular task. It encompasses many beliefs such as whether the task is seen as interesting, accomplishable, valuable, or in alignment with one's sense of self and their belonging among others. Motivation can be supported, increasing the chance of participation in a task, or unsupported, decreasing the willingness to engage in a task. For example, a female student's interest in computers might encourage her to sign up for a summer camp focused on coding. However, the lack of other female participants on the first day may lead her to believe that computer science is not meant for her. In this case, interest promotes movement towards STEM, while lowered sense of belonging reduces it. Rural students' motivation for STEM can also be impacted by teachers' motivation for providing STEM learning opportunities within rural classrooms. For example, a teacher who was trained in math education but asked to teach science due to a shortage of teachers at a rural school may feel less competent in delivering innovative lessons designed to spark student engagement in science. This may also result in the teacher leaving their position. However, professional development opportunities in science instruction could potentially improve the teacher's competence and retention. Due to this reciprocal relationship between student and teacher motivation within the classroom, supporting rural STEM education requires research of each of these populations in tandem.

Measurement of motivation in any educational domain is made complex by the many ways in which motivation is conceptualized within academic literature and the overlap of "fuzzy but powerful constructs" (Pintrich, 1994, p. 139) within prominent theories of motivation. For example, situated expectancy-value theory (SEVT, Eccles & Wigfield, 2020) answers the questions of whether individuals believe they will be successful at a particular task (expectancy for success) and whether they believe the task is important (task value). Within this framework, one of the four major components of task value includes the intrinsic value, or the inherent enjoyment of a task experienced by the individual. Similarly, Ryan and Deci's self-determination theory (2017) also discusses competency and elements of intrinsic motivation. Within self-determination theory, competency, autonomy, and relatedness are regarded as the central psychological needs which must be satisfied in order facilitate intrinsic motivation needed to encourage specific actions (Flannery, 2017). Thus, while the theory behind both examples differs, commonalities exist regarding the importance of corresponding constructs.

Furthermore, motivation for STEM may be influenced by factors beyond people's thoughts about their skills and the value of a task. It is also connected to the behaviors that they engage in that reinforce their beliefs (Stankov & Lee, 2014). This process is highlighted by the reciprocal relationships found between affect, environment, and behavior described in Bandura's (1986) social cognitive theory. This theory posits that *interactions* between environmental, behavioral, and personal factors shape human functioning. In other words, how one feels within a particular context not only shapes their behaviors, but behaviors also impact the way that one feels. Thus, I chose to focus on six broad cognitive and non-cognitive constructs found within research on academic motivation as opposed to single theories of motivation. Each of these six constructs and their relationship to motivation in STEM is briefly described below.

Motivational Themes in STEM Education

Identity

Identity refers to the way in which an individual is viewed as fitting in within a particular environment (Carlone & Johnson, 2007; Hughes, Nzekwe, & Molyneaux., 2013). STEM identity, specifically, addresses the question of whether a person perceives themself and whether others perceive the person as someone who fits in or belongs within STEM environments (i.e., a "STEM person"). STEM identity has been positively associated with many STEM-related outcomes including retention in STEM fields (Perez, Cromley, & Kaplan 2014), career commitments in STEM (Chemers, 2011; Dao et al., 2018), achievement in STEM (Seyranian et al., 2018), and pursuit of STEM majors (Graham et al., 2013). However, STEM identity may be threatened by stereotypes regarding what makes an individual fit in within science. Historically, scientists have been thought of by children as brilliant, white men who conduct research within a laboratory (Chambers, 1983; Finson, Beaver, & Cramond., 1995; Bian, Leslie, & Cimpian, 2017). Although these beliefs are showing some signs of becoming more egalitarian (Miller et al., 2018), they have remained relatively stable over time through various social factors such as stereotyped portrayals of scientists in children's books (Kelly, 2018), lack of diverse STEM role models (Gladstone & Cimpian, 2021), and the implicit messages received from outside sources such as parents and teachers (Crowley et al., 2001; Galdi, Cadinu, & Tomasetto, 2014). Furthermore, the ability of students to see themselves as a scientist can also be impacted by their access to STEM learning opportunities and resources. Students with access to the fewest number of resources have greater difficulty with seeing science as "for them" (Archer et al., 2012).

Belonging

Related to identity is the sense of acceptance and membership experienced by individuals within a particular environment, known as belonging. The importance of belonging comes from Ryan and Deci's concept of relatedness within Self-Determination Theory (2017). This theory posits that the need to feel belonging and connection to others is one of three central components to motivation. It proposes that action within a particular domain is often initially prompted by a desire to become closer to a significant other (e.g. peer, teacher, parent), and maintained through continued attachment (Ryan & Deci, 2000). Within a classroom, feelings of belonging can be fostered through a variety of social and non-social cues which signify a student's importance within that space. For example, practices such as dedicating time to get to know students personally, encouraging students to work together towards common goals, and creating safe environments with access to tools which address the diverse needs of students have all been found to promote belonging within both physical and virtual classrooms (St-Amand, Girard, & Smith, 2017; Thomas, Herbert, & Teras, 2014). Belonging has been linked to positive outcomes such as persistence in STEM fields. For example, students with higher sense of belonging in math are more likely to have future aspirations in mathematics (Good, Rattan, & Dweck, 2012). Conversely, factors such as race or gender stereotyping have been found to reduce sense of belonging and result in movement away from STEM, particularly for women and Students of Color (Cheryan et al., 2011; Rainey et al., 2018; Campbell-Montalvo et al., 2021).

Value

Value regards the importance of a task to an individual. Many students continue to view science and technology as an important field (Potvin & Hansi, 2014). However, fostering value in STEM requires students to not only view STEM fields as important generally, but to see them as important *to them personally*. This includes the importance of STEM learning opportunities to accomplishing future goals (utility value) and the ways in which STEM is viewed as personally meaningful (attainment value; Eccles & Wigfield, 2020). Intrinsic or interest value concerns the positive emotional responses elicited from a task which encourage self-sustained engagement with the task. Value for STEM disciplines is positively associated with motivation for STEM. For example, asking to students to write about the relevance of statistics to their own lives positively impacted their value, interest, and performance in statistics (Acee & Weinstein, 2010). On the other hand, misalignment of student values and STEM disciplines can negatively impact students' choice to pursue them. For example, the perception of STEM as an isolated field of research discourages students who value community from pursuing these fields (e.g. Diekman et al, 2010). Furthermore, value misalignment is often higher in STEM fields which raise greater ethical questions such as those involving topics on animal research, use of human subjects, or evolution of species (e.g. genetic engineering; Taber, Billingsly, & Riga, 2021). Differences in teacher's value for specific content may also impact their desire to teach students about these fields, thereby impacting students' knowledge of and preparedness in these areas.

Competency

Whether or not someone believes they can successfully complete a task describes their competence beliefs for that task. In general, individuals who hold higher beliefs that they can do a specific task are more motivated to do the task, and vice versa (Eccles & Wigfield, 2020). Under the umbrella of competence beliefs are several related terms. These include self-efficacy (the belief of success at specific task, e.g. passing a math test), perceived competence (how skilled one views themselves in an area), and expectancy for success (belief that a person will succeed on a future task; e.g. get an A at the end of the semester). While each of these terms are defined slightly differently, they often play a similar role across motivational theories, and studies suggest empirical overlapping of these terms when considered within a single domain (Wigfield, 1994). Competence is an important component of motivation for both students and teachers. Student competence can be built through mastery experiences and establishment of a mastery goal orientation towards academics. Teacher's competence beliefs for teaching also positively relate to educational outcomes such as better instructional strategies, decreased burnout, and higher retention (Zee & Koomen, 2016). For STEM educators, each of these outcomes would correspond to the chance of providing quality and consistent STEM learning opportunities.

Engagement

Engagement is a motivation-related construct which explores active involvement or commitment with a task. Students who are active in their own learning are more motivated to learn and persist in school, and vice versa. Although, debates as how best to measure and define engagement in academics exist (Appleton, Christianson, & Furlong, 2008), Fredericks (2004) provides a meaningful way to distinguish between three types of engagement common within academic settings: behavioral engagement, cognitive engagement, and emotional engagement. In education, behavioral engagement refers to the physical interactions that students have with class materials (e.g. number of times logging into class) while cognitive engagement captures the mental exertion towards course topics (e.g. participating in class discussion). Emotional engagement includes the affective responses towards school, such as enjoyment, boredom, or interest. While engagement does not equate to retention in STEM fields, it is regarded as a necessary precursor of this outcome (Ohland et al., 2008). Furthermore, shifting motivation for engagement in STEM from externally driven to internally driven has been found to play a vital role in students' choices to pursue STEM learning opportunities and interest in STEM long term. Although there are many ways in which student interest in STEM can be developed, teachers are considered important gatekeepers of developing early STEM interest within formal education settings (Maltese & Tai, 2010; 2011; Maltese, Melki, & Wiebke, 2014).

General Motivation

Despite these nuanced ways in which to describe motivation, the term "motivation" itself is often used colloquially (E.g. She is motivated in science class. He lacks motivation to do his science homework). When motivation is discussed in this way, it is important to note that it could potentially ascribe to many different sources, that may or may not be captured within the categories described above. For example, motivation may also be driven by external factors such as parent expectations, fear of negative evaluation, or recognition. Thus, motivation may also be defined more generally.

Research Purpose

In education, the designation of schools as either urban, suburban, or rural is often established by census data which delineates location based on population size and relative distance from urbanized areas (NCES, 2021). Because rural schools often constitute the smallest percentage of school enrollment and are typically located within remote areas, this population is often overlooked or unfairly disadvantaged in educational policies and interventions, including those to promote STEM retention and persistence (Jimerson, 2005; Bryant, 2010). This paper seeks to enhance understanding of ways in which to support rural students in STEM by focusing on the role of motivation in the context of rural STEM classrooms. Motivation is a key ingredient to participating and persisting within STEM fields across a lifespan. Thus, understanding the ways in which motivation has been studied in rural STEM classrooms allows researchers to better understand the factors contributing to underrepresentation of rural students in this field and better support this population in pursuing STEM learning opportunities and careers. Through the process of a systematic review, I sought to understand the extent to which motivation has been explicitly studied in rural STEM contexts. I hoped to gain insights into the role motivation plays in strengthening rural STEM education as well as potential areas of motivational inquiry yet to be explored.

This research focused on four primary objectives based on the understanding that motivation is important to the success of educational initiatives designed to increase participation and diversity of individuals within STEM. The first research objective focused on describing the characteristics of rural populations in which motivation for STEM has been studied as well as the methods utilized to study it. Considering the complexity of motivation, the second research objective sought to organize articles along the six broad themes described above in an effort to better understand what research regarding motivation for STEM has been done within rural contexts as well as identify future areas of research yet to be explored. The third research objective was to discuss the application of research on motivation for STEM in rural contexts. In this, I offer a counternarrative to the deficit-laden language surrounding rural STEM education by highlighting the ways in which motivation for STEM has been successfully supported in rural communities through positive educational practices. For the final objective, alternate avenues of future support based on promising motivational theories are provided. The following three research questions were used to guide this process:

1. *Whose* motivation has been studied and *how* has motivation been studied within rural STEM contexts?
2. *What* motivational themes have been studied within rural STEM contexts?
3. How can motivation theories be *applied* to support rural STEM education?

Methods

Review of Literature

My review of the research on rural STEM motivation was completed in March of 2021. For this review, I conducted a total of 10 searches by combining the key terms *rural* with either *STEM* or *science education* and one of five terms related to motivation (*motivation/ identity/ engagement/ self-efficacy/ interest*). The searches were conducted across 12 electronic databases: Academic Search Complete, APA PsycArticles, APA PsycInfo, Child Development & Adolescent Studies, Education Research Complete, Educational Administration Abstracts, ERIC, Psychology and Behavioral Sciences Collection, Race Relations Abstracts, Social Work Abstracts, SocINDEX with Full Text, Sociological Collection. I chose to include databases supporting multiple fields of research (i.e. sociology, psychology, child development) in order to capture the broad ways in which motivation may be discussed. Inclusion was limited to full-text, peer-reviewed articles which were available in English.

A multistep screening process was used to obtain final articles used for analysis (Figure 1). Following the deletion of duplicate articles, I screened article titles and abstracts for relevancy to the topic of motivation in rural STEM education. Any articles whose relevancy could not be determined from reading the abstract were retained for the second round of screening in which the full text was read to determine relevancy. There were several examples of relevancy exclusions. Papers in which keywords were used in non-applicable contexts (e.g., “plant *stem* growth,” “*rural* migration”) were excluded from review. In addition, papers which did not measure constructs related to student motivation, but only included the motivation-related terms as part of a future direction or introductory statement, were also excluded. Because I was specifically interested in rural populations, studies which measured motivation in mixed populations (e.g. rural and urban students) but did not differentiate outcomes by geographic location were also excluded. No limitation was placed on the date which articles were published so as to capture the breadth of peer-reviewed research on motivation in rural STEM contexts. The earliest paper which met search criteria was published in 1929.

Coding

Initial coding was conducted by two trained independent researchers until an acceptable threshold of interrater reliability was met (percent agreement > 75%). A total of 119 papers were included within the review. Percent agreement for each general code was greater than 76%. Average percent agreement for each subcode was greater than 77%. During this process, coders met to identify differences, and all discrepancies were resolved through discussion. Once coders established an acceptable reliability on a minimum of 25% of the articles, all remaining articles were independently coded according to the finalized coding guidelines.

Identification of Who and How

Articles which met the inclusion criteria were first reviewed to determine the specific demographic and methodological characteristics of each. A full description of each of the characteristics and the coding schemes used to describe them can be found in Table 1. Demographic characteristics included study population, ethnicity of the population, research focus, and location of study. Study population was coded according to the population type, student or teacher, as well as grade level, pre-school, elementary school, middle school, high school, or post-secondary education, or pre-service educator. Grade levels were based on conventional age and grade ranges found within the United States. An "other educators" category was also included to capture individuals within education who are not classified as teachers, such as principals or school librarians. Population ethnicity categories included American Indian/Alaskan Native, Asian American/ Pacific Islander, Black/African American, White/European American, Hispanic/Latino/a, multiracial, or not given. To be given a single ethnicity code, 80% or greater of the study population had to consist of a single ethnic group. Multiracial codes were given if no single ethnic group comprised greater than 80% of the population. "Not given" was selected in instances in which no information about ethnicity was provided. The purpose of the study as it relates to rural populations was coded under the category labeled "research focus." In this category, papers were coded based on whether the paper investigated only rural populations or whether populations were from mixed locations. Rural-only populations were further coded based on whether they represented a convenience sample or not. In other words, was the rural sample selected because it was in a rural location or because of its availability to the researcher. Finally, the country in which the study took place was coded for under "location." Countries included United States/Canada, Europe, Africa, Asia, South America/Latin America/Central America, and Australia/Oceana.

Methodological characteristics included the methodological approaches and whether the study contained a longitudinal design. Articles were first coded as either using qualitative, quantitative, or mixed methods. Qualitative studies illustrate research outcomes by using participant language to describe findings within context but may be limited in their generalization and replication. Quantitative studies focus on valid and reliable numerical measurements to generalize findings across populations. However, quantitative studies may place less emphasis on the unique context in which the research occurs. Both may be used in conjunction to minimize the shortcomings of the other, in what is known as mixed-methods research.

Next, articles were identified according to whether they contained an intervention and whether they were longitudinal. I defined interventions studies as research in which teaching and/or learning strategies were introduced to the population and their impact on motivational outcomes were determined. For students, interventions included practices such as providing access to new technology or research opportunities. For teachers, interventions typically focused on professional development and curriculum training. To be considered a longitudinal study, the same outcome variables had to be measured across multiple time points with a minimum threshold of 1 week between repeated measures. Measurements could be done in the same participant (e.g. aspirations in science measured at the end of 5^{th}, 6^{th}, and 7^{th} grade for a single student) or cross-sectionally among different participants across time points (5^{th}, 6^{th}, and 7^{th} grade students' aspirations in science). Finally, because there remains a lack of standardization on how to define the term *rural* and debates as to how best to categorize rural schools still exist

(Hawley et al., 2016), papers were also reviewed for whether they attempted to describe or define the term rural in an effort to distinguish rural schools from other locations.

Identification of Motivational Themes

Next, each study was reviewed to determine the motivational themes present. The codebook used to identify motivational themes can be found in Table 2. As discussed within the introduction, six broad cognitive and non-cognitive themes of motivation were selected based on their prominence within research on academic motivation broadly. For each article, motivational themes were coded as either present (1) or not present (0). Each motivational theme identified as present, with the exclusion of belonging, was then sub-coded for the specific motivational concept discussed within that theme. For instances in which a subcode could not be clearly identified, the subcode was designated “undifferentiated”. Coding for motivational themes present in teacher populations were coded separately from student populations to analyze trends regarding what types of motivation were measured in each population.

Although papers could be coded for multiple motivational themes and subcodes, inclusion boundaries were created in order to best capture the most prominent themes present in each study. For studies which utilized quantitative methods, thematic codes were assigned based on what motivational theme(s) the authors of the study empirically measured. For example, if the participant was asked to rate their enjoyment of a STEM activity on a scale of 1 to 10, then a measurement of engagement was coded as present, and the paper was sub coded as measuring emotional engagement. For qualitative studies, codes were assigned based on the theme(s) emphasized or highlighted by the author of the study. For example, if a teacher was asked to describe their confidence in teaching engineering, then the theme of competence was coded as present, and the paper was sub coded for self-efficacy. Qualitative and quantitative themes of mixed methods studies were coded separately to allow for analysis of trends in methodological approaches for motivational themes. Although rare, a few discrepancies arose in which the theme described by the author did not align with the description of that theme within the codebook. In these instances, the theme was coded in alignment with the description provided within the codebook.

Analysis

This paper sought to use a descriptive approach to understand how motivation has previously been studied in rural STEM contexts and areas of research in need of further exploration. Thus, all final codes were imported into IBM SPSS and descriptive statistics such as frequency and percentage were examined. These values were used to analyze patterns and trends in who and how motivation has been studied (RQ1), what motivational themes were present in the literature (RQ2), and how these themes may be applied to support rural STEM education (RQ3).

Results

Whose Motivation Has Been Studied?

Defining Rural

In order to understand the ways in which researchers conceptualized the term “rural,” I first looked at whether authors attempted to define or describe the characteristics of a rural region. Only 19% of the articles used objective measures such as population size or distance from an urbanized area in describing the location of their study. Instead, authors were almost equally likely to use rural as a descriptor term without providing any definition or description (40% of articles) as they were to provide a deficit characterization of the rural region, such as lacking in access to technology (36% of articles). When no objective definition is given, the interpretation of the term “rural” is left to the views of the reader or, in the case of the study conducted by Baird et al. (1994) which allowed for self-selection of location, to the views of the participant. Thus, without context of what it means for a place to be labelled as rural, the generalization of where or under what circumstances the study should be replicated becomes subjective and unclear.

Location

Over half (59%) of the articles included within this review originated within the United States or Canada. This was followed by Australia (16%), Asia (13%), Africa (7%), and Europe (6%). No articles originating in South or Latin America were found. As such, the findings within this review are biased towards primarily Westernized, English-speaking nations.

Ethnicity

The ethnic backgrounds of the participants reviewed were also non-representative of the overall population. Outside of the United States, it is less common to report the ethnicity of participant populations. Within the international studies reviewed, only three reported the ethnicity of the participants. However, reporting of participant ethnicity is standard practice for many publishers of educational research in the United States and considered recommended practice of writing according to American Psychological Association guidelines (APA, 2019). Therefore, analysis of the ethnic backgrounds of participants was limited to only those studies occurring within the United States (n = 69, Figure 2). However, 58% of the articles within this review that were conducted within the United States did not include information on participant ethnicity. The remaining 42% of the articles that did report ethnic information consisted of multiracial populations (19%), White or European American populations (16%), American Indian/ Alaskan Native populations (4%), Hispanic/ Latino/a populations (1%), and Black/

African American populations (1%). No Asian American or Pacific Islander populations were represented within the United States.

Research Focus

The research focus of 54% of the articles was to gain insights into research outcomes specific to rural populations, as opposed to using them as a comparison group to non-rural populations (28%) or as a convenience sample (19%).

Population

Of the 119 articles, 57% measured student motivation only, 22% measured teacher motivation only, and 20% measured motivation of both students and teachers. Studies measured motivation for STEM in rural contexts primarily across elementary, middle, and high school grade levels for both students and teachers (Figure 3). However, fewer studies explored pre-school and post-secondary student populations or pre-service and post-secondary teacher populations. No articles measuring motivation of pre-school teachers were found.

How Has Motivation Been Studied?

Methodological Approach and Longitudinal Design

Approximately equal emphasis was given to each type of research method. Within the articles 36% utilized qualitative methods, 34% quantitative, and 30% mixed-methods. Interventions occurred in 36% of the articles. This includes 35% of articles which explored outcomes qualitatively, 50% of studies which explored quantitative outcomes, and 23% of mixed method studies. However, knowledge of the lasting impact of these interventions is limited by the lack of longitudinal research extending beyond a single school year. Because I utilized a week between repeated measures as a minimum threshold for defining longitudinal research, 45% of the articles were coded as longitudinal. Yet, less than 10% of all articles included measurement of motivation outcomes extending beyond a single school year.

What Are the Motivational Themes?

To better analyze trends in motivation, results pertaining to teacher motivation were analyzed separately from results pertaining to student motivation. If a single paper analyzed results from more than one of these populations, they were independently assessed for the motivational outcomes of each population. For example, if a paper surveyed both elementary teachers and elementary students, then the motivational outcomes of each of these populations were coded separately. Accounting for papers which measured more than one population resulted in a total of 151 separate cases for analysis. Each case could also be coded for multiple forms of motivation. To view the breakdown of cases by motivation category and population, see Table 3.

Each of the motivation-related constructs within the coding scheme could be found within the literature, but to varying degrees. Engagement was by far the most frequent motivation construct examined throughout the articles. It was observed in 102 of the 151 cases. For the cases which studied engagement, emotional engagement/interest was the most studied subcategory. Measurements of competence beliefs, value, and identity were found in 55, 46, and 38 of the total number of cases respectively. General motivation followed by belonging were reported the least of all the motivation constructs. The types of motivation studied also depended partially on the population (students vs. teachers). Specifically, teachers' competence beliefs were studied almost as frequently as the most common code of engagement while all other constructs of teachers' motivation were targeted less frequently.

How Can Motivation Research Be Applied?

In reviewing the literature, I identified common themes in the way in which motivation has been used to understand how to support rural STEM education. Within this section, I chose to take a critical approach to motivation in rural STEM education by focusing on how motivational themes correspond to positive educational practices frequently implemented to address barriers which are more common within rural settings. I chose to focus on the strengths of rural communities as a means of reducing the deficit-laden narrative surrounding rural STEM education and the incidence of rural stereotyping within this context. These strategies include promoting student engagement through partnerships, fostering identity and belonging through culturally relevant and place-based educational practices, and building teacher competency through curriculum training.

The Issue of Generalizations and Group Comparisons

By providing a definition or description of the term rural, researchers allow for the generalization and replication of findings in areas which have similar features of rurality. For example, if the objective of a study was to reduce the educational inequities in STEM education experienced by rural students due to limited of access to technology, then the same method may be applied to other rural regions in which technology is scarce. In this way, the 36% of the articles that characterized rural regions by emphasizing challenges such as inadequate resources, isolation, teacher retention, and poverty reflect current approaches in rural education which justify research by focusing on the educational challenges of these regions to be addressed (Stelmach, 2011). However, this approach has also contributed to stereotypes that rural status equates to an educational deficiency and the creation of students who are perceived as sub-par and unmotivated to learn (Azano et. al., 2021; Azano, 2015; Theobald & Wood, 2010).

Furthermore, these challenges are negatively reflected in preservice teacher's perceptions of rural education and explanations against working in rural communities, particularly among pre-service teachers who lack experiences in rural communities (Todd & Agnello, 2006; Richards, 2012; Hudson & Hudson, 2008). Thus, care must be taken to define rurality so as to avoid the assumption and generalization of deficits across this context.

Furthermore, studies which compared levels of general motivation across groups within rural contexts were more likely to emphasize outcomes suggesting inherent differences between these groups. A total of 7 papers compared general motivation across groups. Example of groupings included different locations, different gender, and different race. The one study which focused on motivational differences by location found no differences between groups. (Kitts, 2009). However, when considering differences by gender or race, motivational deficiencies aligned with gaps in representation such that. females, and Students of Color within rural communities were seen as having lower motivation, higher attrition, greater avoidance, more external pressures, less academic rigor, and more disadvantages in STEM fields (Chithprabha & Kanekar, 1995, Desy, Peterson, & Brockman, 2009; Johnston & Winterbottom, 2001; Gilbert & Yerrick, 2001; Young, Frasier & Woodbough, 1997; Liu & Neuhous, 2014). However, these findings should be interpreted cautiously. As opposed to forming generalizations about the inherent motivational differences between individuals within rural contexts, use of a critical lens when discussing differences calls for evaluation of systemic barriers and the removal of blame from the victims of systemic inequities (Crenshaw, 1995) Thus, characterizing rural communities by their strengths, or at minimum, give equal consideration to both strengths and challenges, represents a potential strategy to reducing the incidence or rural stereotyping.

Only 4% of the articles included within this review took a strengths-based approach to describing the term rural. Usher and colleagues (2019) categorized rural regions by describing both supports and barriers present within rural communities which may influence students' development of self-efficacy. In contrast, the remaining fours studies only characterized rural communities by positive attributes. Two, Dvorak, Franke-Dvorak, & Neel (2016) and Heald (1929), chose to emphasize students' participation in agricultural practices as having potential to support educational interventions which emphasized skills related to agriculture and engineering. Tytler et al. (2008) and Allen et al. (2020) each highlighted the ways in which the strong community ties characteristic of many rural regions could be leveraged to support students in STEM. Within these examples, the need for and the justification of research remains, but the barriers become a byproduct of educational inequities as opposed to inherit deficit characterizations of rural communities and people. Thus, this critical approach is continued within the next section which focuses on ways to support STEM motivation within rural contexts.

Supporting Engagement and Value

Engagement, or the behavioral, cognitive, and emotional participation in a task, is how many researchers conceptualize the process of doing science. Students and teachers must first engage in STEM learning opportunities to determine their willingness to continue to participate in the field. For rural classrooms, exposure to and engagement in STEM learning opportunities is often limited by the number of resources available to the school. An educational practice common in rural communities used to address this limitation is to create partnerships between university, community, and/or government organizations and schools. These partnerships utilize the relationships that already exist between rural STEM teachers and students but bolster the learning environment by providing access to resources which may otherwise be unavailable. Within the literature, the resources provided to rural STEM classrooms from partnerships with universities, community organizations, and governmental programs were wide-ranging. They included STEM mentors (eg. Li, 2010; Scogin & Stuessy, 2015); technology (eg. Dickerson & Kubasko, 2007; Matson, DeLoach, & Pauly, 2004), STEM programming (eg., Ihrig, 2018; Blake & Campbell, 2009), and new curriculum (eg., Klopp et al., 2014; Missett et al., 2010).

Partnership studies took the form of interventions to see specifically how providing access to STEM resources influenced engagement with STEM within rural populations. However, best practices in how to measure engagement and how to relate engagement outcomes to motivation outcomes remains a challenge within educational research (Fredericks, Hofkens, & Wang, 2019). Measurement of engagement can be influenced by a number of factors including classroom environment, when engagement is measured, reporter or recorder bias, and personal characteristics of the participants. Many of these challenges were present within the articles in this review. For example, Nicholas (2009) and Won, Evans, & Huang (2017) both found that interpretations of engagement were biased towards the reports of participants who continued to partake in the study while the outcomes of participants who declined in participation were lost over time. This means that a program may appear to be engaging students but may be excluding students who disengage because their participation is no longer being assessed. Ruopp (1993) describes how differential outcomes may exist for students based on individual student characteristics. In their study, introduction of telecommunications practices in the classroom created enjoyment for some students, but the act of communicating online caused anxiety for others. Finally, Scogin (2015) found that providing access to e-mentors promoted student engagement in STEM. However, differences in the ways in which the mentors supported student autonomy, competence, and relatedness had differential effects on student engagement. Engagement was found to be highest when student relatedness was supported. Thus, the challenges of measuring engagement make the interpretation of engagement results difficult, particularly in the 29 articles that only measured engagement as an outcome.

Three different subcategories of engagement were considered: behavioral engagement, cognitive engagement, and emotional engagement/Interest. Of these, emotional engagement/interest was by far the largest category and was assessed in over 80% of the papers which measured some form of engagement. It was also found in 53% of the total studies overall. Six of the articles which measured emotional engagement/interest did not include an intervention; Five measured interests in science at a single time point (Halder et al., 2012; Kier et al., 2014, Asian & Aslan, 2009; Clarke, 1972; Lin & Crawley, 1987) while one looked at the decline in interest across middle school (Skamp & Logan, 2005). However, all remaining papers described partnerships in which participants' emotional engagement/interest was measured either during or immediately following an intervention.

Positive feelings and increased interest were reported in response to a variety of novel resources such as using a Wii to learn physics (Dvorak, 2016), using iPads to learn math (Miller, 2018), using social media to learn science (Won, 2017), using art to learn about fossils (Klopp, 2014), and, for teachers, using project-based learning activities to teach about renewable energy (Ertmer et al., 2014). However, because of the lack of longitudinal data regarding interest development for STEM following these interventions, it is possible that this interest reflects situational interest only (Hidi & Renninger, 2006). In other words, the participants reported interest and enjoyment in the activity during or as a result of the exposure itself, and not because of a lasting personal interest for the activity. Thus, partnerships provide an important means of gaining access to resources within rural communities which can spark initial interest in STEM learning opportunities. However, the long term-impacts of these initiatives requires further longitudinal research or measurement of engagement outcomes alongside more stable forms of motivation.

For instance, twelve partnership studies within the literature addressed this limitation by measuring both engagement and value for the intervention. Value reflects the importance of a task to an individual. It includes utility value, or the importance of a task to a future goal, and attainment value, or the personal importance of a task. For example, a future doctor may choose to volunteer at a local clinic because it allows them to both practice skills (utility value) and help others (attainment value).

Within these studies, partnerships not only provided a missing resource, but the resource given was directly relevant to the location and experiences of the participants in which the intervention occurred, thereby increasing value for that experience. Sharma (2008) found that, in India, students' personal experience with trying to improve the output of limited electrical resources allowed them to take more agency of their work and find their work more meaningful when learning about electrical circuits. Thus, value was used to promote students' behavioral and cognitive engagement in a lesson on electricity. Considerations of value can also be extended beyond individual importance or relevance. Other studies measured value as a result of providing curriculum and learning experiences relevant to community needs such as creating sustainable resources and jobs (Tytler et al., 2008); assessing the impact of a local dam failure (Boynton & Hossain, 2010); agricultural practices (Heald, 1929); wildlife management (Ash, Carlone, & Matthews, 2015); and exploring human and nature interactions (Lindemann-Matthies, 2006; Mammadova, 2017). By providing novel resources which are personally meaningful, these partnerships expand the interpretation of the intervention beyond just “Did I participate in a STEM learning opportunity and find it enjoyable?” to encourage participants to consider the lasting effect of “Why is STEM work important to me, my community, and my future?”

Supporting Identity and Belonging

Similar to value, identity and belonging can be fostered by creating ties between STEM learning or teaching, culture, and place. However, instead of answering the question of why STEM is important generally, identity and belonging focus on the ways in which individuals see themselves as fitting in and being accepted in STEM environments. Studies which focus on identity and belonging in rural STEM learning contexts answer questions such as: As a teacher who grew up in an urban area, will I be accepted in a rural classroom? Can I connect to my students from different backgrounds? Do people from rural areas have jobs in STEM? Or, do my personal beliefs align with those of a scientist? Thus, practices to support rural STEM identity and belonging must allow students to align their perception of self with someone who belongs in STEM. The strategies employed to achieve this goal in rural communities typically include culturally relevant pedagogy and place-based education.

Culturally relevant pedagogy has its roots in critical theory (Ladson-Billings, 1995). It promotes students’ learning by encouraging educators to incorporate elements of student culture into the classroom. It was specifically designed to highlight voices which are underrepresented within a field. Culturally relevant pedagogy is considered a critical component of place-based education. Place-based education highlights aspects of location, such as physical space, history, or culture, to help students see themselves within the curriculum. Thus, culturally relevant pedagogy and place-based education are complementary practices which can be used to positively highlight student identity and belonging within a field

In reviewing the literature, 15 papers looked at the influence of culturally relevant and place-based pedagogical practices on STEM identity and belonging. To highlight the interconnections of place-based and culturally relevant-pedagogy in three rural STEM community college classrooms, Birt & Siegel (2020) discussed how drawing on students' identity requires educators to create STEM materials that are connective, attentive, rigorous, and expansive (CARE). For example, after realizing how long commute times of her rural students impacted their ability to finish homework, one educator restructured her classroom so that homework was no longer assigned, and greater emphasis was placed on demonstrating knowledge through in-class group learning activities. Furthermore, mastery of in-class content was aligned to the individual goals and needs of her students. Thus, effective use of culturally relevant and place-based instruction relies on the ability of educators to establish personal relationships with students, which promotes belonging in the classroom.

Culturally relevant pedagogy and place-based education were also used to look at the influence of intersecting identities such as STEM identity, rural identity, gender identity, ethnic identity, etc. on student's STEM outcomes. Fostering identity and belonging in STEM by successfully incorporating elements of student identity into STEM curriculum was consistently linked to positive STEM outcomes. For example, asking students to include Indigenous beliefs in their projects was found to increase the participation of Native American students in state science fairs (Dublin et al., 2014). Furthermore, Black students were found to be more successful in STEM when provided with role models and peers of the same culture (Collins & Jones Roberson, 2020). Incorporation of local practices and beliefs were also found to improve factors such as science learning and discussion (Harper, 2017; Keane, 2008) and ability to see future-selves within science (Kier & Blanchard, 2021).

Failure to recognize the influence of place and culture was found to negatively impact student STEM outcomes. For example, the objective of Schabort, Sinnes, & Kyle (2018) to empower rural female African students through education in STEM could not be met because other place-based needs such as hunger, security, and resources, had to be met first. Quinn & Lyons (2016) also highlighted the careful balance of place-based education with the needs of the region. They discuss how rural students in Australia are more likely to pursue agricultural sciences because of their place. However agricultural jobs within the area were declining. Thus, they suggest that educators should strive to not make the influence of place so narrow that opportunities for students become limited. Culturally, strong ties were found between familial relationships and science identity within rural communities (Stahl et al., 2021). As such, failure to consider the role of familial expectations, and particularly the difference in expectations for sons and daughters, was a common factor found throughout the literature to contribute to underrepresentation in STEM (Kier & Blanchard, 2021; Liu & Neuhaus, 2020; Naugah & Watts, 2013; Gilbert & Yerrick, 2001).

Despite this evidence regarding links between STEM outcomes and identity factors such as race, gender, culture, and familial expectations, approximately two thirds of the articles which measured identity did not measure identity markers outside of STEM identity. Thus, additional research on intersectionality represents an area of future research to explore. Furthermore, only 20% of the articles which measured identity and/or belonging focused on teacher identity and belonging. Within the literature, the alignment between elements of teacher identity and classroom environments was found to influence STEM teaching practices. For example, Brand & Glasson (2004) found that sharing a rural identity with his students made a single preservice educator feel that he could better relate to his students in the science classroom. Alternatively, Hobbs (2012) found that out-of-field teaching experiences as a result of teacher shortages were found to detrimentally impact teaching identity for STEM teachers. Out-of-field teaching experiences, which are common in rural areas due to limited teacher availability, occur when educators who are trained in one discipline (i.e., math) are asked to teach related fields outside of their specific training (i.e., science). Hobbs found that many of these teachers who had not established a professional identity within the field they were being asked to teach, felt that they were "just making the most" of their situation Out-of-field teachers were found to question their identity as a teacher, rely on engaging lessons to attempt to spark student interest, and participate in less professional development and retraining in their new discipline. Although another study suggested the creation of learning communities for out-of-field teachers as a potential solution for improving teaching identity (Kilpatrick & Fraser, 2019), no evidence of interventions or strategies to support teacher identity were found within this review. Thus, additional research exploring the ways in which teacher identity and belonging can be supported within rural STEM contexts is needed.

Supporting Perceptions of Competence

Competence, or individual judgements of skills and abilities, is a powerful predictor of whether an individual will engage in an activity. Within this review, 36% of papers assessed competence beliefs. Where identity and belonging studies overwhelmingly assessed student outcomes, studies which measured competency primarily centered around teacher outcomes. Competence beliefs were measured in 30% of all papers which measured motivational outcomes of teachers as opposed to only 15% of papers which measured student's motivation outcomes. Facilitation of teacher competency has been linked to several positive classroom effects. These include improved quality of instruction, increased job satisfaction, higher levels of retention, greater emotional well-being, and positive effects on students' motivation and academic achievement (Zee & Kooman, 2016). Higher teacher competency is also linked to better outcomes for STEM classrooms specifically (Zakariya, 2020; Fauth et al, 2019; Woo et al, 2018). As such, strategies which support teacher self-efficacy represent a potential solution to addressing gaps in rural STEM representation. Within the literature, these strategies primarily took the form of training programs which measured initial educator self-efficacy as either a baseline assessment prior to intervention or following training in and implementation of novel classroom techniques.

Three articles explored levels of competence at a single time point. In one, rural STEM educators were found to report low self-efficacy for technology (Marksbury, 2017). Two measured the baseline self-efficacy of rural librarians who serve instructional support roles for teachers. Although Johnston (2018) found that librarians in rural areas felt that they lacked the proper training to address the STEM instructional needs of rural schools, Verbeke and colleagues (2019) found that self-efficacy positively related to rural librarians' self-perspective as developers of science programming. One study quantitatively explored the relationships between teacher and parent expectancies for their students' success on their student's expectancy for success and achievement in STEM (Thomas & Strunk, 2017). Parents' expectancies were found to be more influential than teachers. Finally, only one study measured perceived competence of pre-service teachers. In this study, competence was measured as it related to pre-service teachers' desires to work in high needs schools, including a rural district (Kier & Chen, 2019). Lower self-efficacy to navigate challenges of high-needs schools was associated with less desire to work in them and reduced decisions to work in high-needs schools following completion of their teacher training program.

For in-service teachers, teaching self-efficacy was measured following six different types of training programs across 11 studies. These programs included training within professional learning communities (Durr et al, 2020), training on how to implement project based learning (Ertmer, 2014), training in culturally responsive teaching (Leonard et al, 2018); engineering professional development (Ficklin, Parker & Shaw-Ferguson, 2020; Parker, Ficklin, & Mishra, 2020), curriculum professional development (Sandholtz & Ringstaff 2013,2014; Sherman & MacDonald, 2008), technology training (Watson, 2006; Borchers & Others, 1992), and distance based instructional coaching (Lee et al, 2018). Each of these studies found improved outcomes on teachers' self-efficacy. This suggests the potential of improving teacher competence as a target in a variety of interventions designed for rural classrooms.

Like with teacher self-efficacy, students' positive self-efficacy in STEM is linked to positive STEM outcomes (Rittmayer & Beier, 2008). However, only four studies were found measuring student competency in rural populations. This limits the ability to draw similar conclusions across rural populations. Like with other student populations, Usher and colleagues (2019) found that sources such as mastery experiences, teacher feedback, and social comparison were foundational to shape rural students' competency beliefs. However, the influence of three intervention studies on student perceptions of competence were found to be mixed. Johnson-Pynn et al. (2014) found increased student self-efficacy because of attending training in environmental education. However, Swanson (2017) found no change in student self-efficacy following practice in drama infused STEM learning. Finally, Starobin et al. (2014) found that implementation of a pre-engineering project program lowered student self-efficacy as compared to a control group. This was thought to be likely due to peer comparison among the treatment group. Thus, additional studies targeting rural students' self-efficacy in STEM are necessary.

Discussion

One-fifth of all school aged children in the United States attend a rural school. These schools are distributed across the various regions of the United States. As such, students who attend rural schools reflect the diversity of the nation as a whole and are uniquely situated to help meet the continued demand for a greater and more diverse STEM workforce. However, rural students continue to remain underrepresented in STEM fields. Due to their remoteness and relatively small population sizes, rural schools are often treated according to an “out of sight, out of mind” philosophy in terms of educational policy and reform. These differences in educational outcomes which result from this neglect are typically discussed in terms of teaching and learning deficits and their negative impact on student’s academic motivation and trajectories. In explaining the gap in the number of rural students in STEM, research points to factors such as lack of STEM learning opportunities, isolation, limited access to resources, and teacher turnover. However, this narrative contributes to rural stereotyping when rural students are compared to other, more advantaged groups. As such, a critical evaluation, which highlights positive educational practices that address systemic barriers and promote rural communities to achieve in STEM, is necessary to counter this narrative.

However, the implementation of educational practices is only the starting point for supporting rural students in STEM. How these solutions influence both student and teacher motivation for STEM in rural areas must also be considered. Many different theories and large bodies of research support the idea that motivation is necessary for positive task outcomes, and each have been extensively applied to education. These theories of motivation encompass the importance of the task (value), the ability to be successful at the task (competency), the congruency of views regarding the task with views about oneself (identity), the ability to be accepted in an area (belonging), and the physical, cognitive, and emotional involvement with the task (engagement). Broadly speaking, where little to no motivation exists, action towards an outcome is unlikely, even when the opportunity for the outcome exists. Alternatively, higher motivation for an action makes the outcome more likely to occur. Thus, motivation represents an important avenue of research in determining the mechanism by which contextual factors are transferred into differential outcomes.

Within this review common themes among educational strategies which were successfully used to support STEM motivation for both teachers and students in rural. contexts were found. These strategies belonged to three primary groups. First, partnerships established between rural STEM classrooms and other university, community, or government associations provided students and teachers access to more resources and opportunities to engage in STEM. These novel learning opportunities promoted both engagement and interest in teaching and learning STEM. Furthermore, partnerships which tied STEM opportunities directly to the experiences and goals of rural communities also increased value for STEM learning. Next, culturally relevant and place-based pedagogical practices were found to increase identity and belonging for students in rural STEM classrooms. Students who were able to see aspects of their own identity such as gender, culture, race, family values, and hometown as congruent with their future in STEM had higher identity in STEM. To know these aspects of identity about their students, teachers must first build strong relationships with their students. Thus, use of culturally relevant and place-based pedagogical practices was also found to increase students' sense of belonging in the STEM classroom. Finally, strong ties exist between teacher competency and positive educational outcomes in STEM. Training programs for rural educators were found to increase teacher competency for implementing new teaching practices in the classroom. Thus, training programs offer a third method for improving STEM learning outcomes for rural students. Each of these strategies offers an action-oriented approach to supporting STEM motivation in rural contexts and demonstrate how addressing systemic barriers can be used to challenge deficit narratives in rural education.

Limitations in Whose Motivation Has Been Studied

Although rural students may evoke a particular image, not all rural students share the same identity or background. Generalization of findings of this review to diverse groups of rural students is limited by the amount of missing information and lack of representation within the reviewed articles. Even after removing all international studies where it is less common to report ethnic identity, 58% of the studies conducted within the United States did not report the ethnicity of the participants. Of the remaining 42% of articles, 19% looked at outcomes of multiracial populations, 16% looked at white or European American populations, and the remaining 6% was split among American Indian/Alaskan Native (4%), Hispanic (1%), and Black/African American (1%) populations. Considered collectively across the United States, rural communities continue to remain primarily white. However, the distribution of racial groups among rural communities is not even. For example, the state of Georgia is ranked within the top five of all states which provide public education to the largest number of rural students (Showalter et al, 2019). A quarter of the rural schools in Georgia serve primarily black students (Williams, Swain, & Graham, 2021). Furthermore, the experiences of diverse rural groups may not the same. For instance, while many individuals in rural areas live in poverty, this percentage is historically higher for marginalized groups within these regions (Lichter et al, 2012). Low socioeconomic status, in turn, has been found to strongly predict participation in STEM disciplines (Cooper & Berry, 2020). Thus, differential experiences among diverse groups of rural populations may impact STEM trajectories differently, making the need for intersectional research on STEM motivation in rural contexts necessary.

Motivation for STEM was measured in both students and teachers primarily situated in elementary, middle, and high school contexts. However, the motivation of populations outside of these grade levels may also be important for understanding how to support rural students in STEM fields. For example, determination of pre-service teacher's motivation for entering rural STEM classrooms may serve as an important gatekeeper to increasing teacher recruitment and retention in these areas. Rural stereotyping combined with the deficit-laden narratives surrounding rural education, may dissuade pre-service teachers from choosing to teach in rural classrooms. However, these stereotypes have been successfully challenged using interventions targeted at increasing teacher's experiences with rural schools and communities during pre-service teacher training (Todd & Agnello, 2006; Richards, 2012; Hudson & Hudson, 2008). Alternatively, teacher recruitment strategies in rural education often seek to select applicants with established ties to rural regions in the hopes that they will return to rural areas to work (Barley, 2009). In this way, rural identity is leveraged to reduce the impact of rural stereotyping on pre-service teachers' perceptions of rural education. Thus, additional research should focus on exploring factors which either support or hinder pre-service teacher's motivation for entering rural STEM classrooms.

Rural post-secondary students represent a second example of a population outside of K-12 settings in need of further exploration of motivational factors influencing STEM retention and persistence. Studies which explore the role of rurality on STEM college aspirations and retention typically focus on the external challenges preventing the enrollment of rural students in STEM majors initially (e.g., Saw & Agger, 2021; Versypt & Versypt, 2013; Kruse et al, 2015).

However, few studies were found which explored the relationship between motivation and rurality on students' outcomes once they entered STEM degree programs. Higher attrition rates have been found among underrepresented groups, such as women, Students of Color, and first-generation students, who declared a STEM major in college (Bettencourt et al., 2020; Riegle-Crumb, King, & Irizarry, 2019). This movement away from STEM has been attributed to several motivational factors. For example, learning environments in which post-secondary educators devalue diverse student contributions has been found to decrease student sense of belonging and threaten STEM identity formation (Hall, Schmader, & Croft, 2015; Larnell, Boston, & Bragelman 2014). As another underrepresented group in STEM, similar findings may exist for rural students. However, additional research is necessary to see exactly how rurality influences motivation in post-secondary contexts.

Limitations in How Motivation Has Been Studied

Limitations in how motivation was studied highlighted the need for measuring and interpreting multiple forms of motivation both as short term outcomes and across time. Qualitative, quantitative, and mixed method approaches for measuring motivation were all captured within this review. However, one difficulty in combining findings from multiple methods of research was how to code qualitative studies for the motivational constructs they discussed. To reduce disagreements, qualitative studies were coded according to the motivation construct emphasized by the researcher. However, qualitative studies are used for exploratory research to identity themes and areas of further exploration by analyzing participants' written or verbal responses. As such, it was often the case that data included within qualitative studies described multiple forms of motivation and better illustrated the ways in which multiple motivational constructs may influence each other even when one form of motivation was emphasized by the researcher. Take for example the following quote within Collins & Jones Roberson (2020) in which a rural, black, male student describes an early experience with math as part of his life narrative in STEM:

> [In Pre-K] I remember when I was introduced to numbers. . . I knew there was something else to them; I wondered what makes two come after one . . . it became a game"; "I remember in kindergarten I used to be bored . . . I already knew it . . . the most memorable moment was not necessarily when I took my Quest [gifted] Test or the reward I got afterwards . . . give those students who think outside the box a reason to go to school. When you think of trailers you think of this nasty place but it was magical; I was excited to go there" . . . "Other than math, there was absolutely no interest whatsoever. I could care less learning that Christopher Columbus sailed the ocean blue in fourteen hundred ninety-two; the history, language arts—I had no use for it whatsoever.

Within this response, there are elements of the student's emotional engagement (bored, interest, excited), external motivation (reward), cognitive engagement (I wondered what makes two come after one), and utility value (I had no use for it whatsoever). However, the focus of the paper from the authors' perspective and therefore the subsequent coding was on identity development. From this example though, it can be seen how other forms of motivation influenced the way that this student saw himself within a STEM field, and his decisions to persist in STEM as opposed to other fields.

Despite this holistic way in which qualitative research discusses motivation to pursue STEM fields, only one study quantitatively measured each form of motivation to determine its relationship with STEM outcomes. In this study, Chittum & Jones (2017) performed cluster analysis on student survey responses regarding their experience in their rural science classroom. Students were clustered into five groups based on their motivation profiles regrading STEM interest, success, usefulness, perceptions of teacher caring, and intentions in future STEM course taking and careers. The five clusters found differed in their motivation profiles and STEM outcomes for rural students. In the first profile, the low motivation profile, intentions for STEM fields were the lowest. In the second cluster, students reported low usefulness and interest, but high success and caring. However, their intentions in STEM remained low. The third profile, the somewhat high motivation profile, had more moderate intentions in STEM, but they were still somewhat low. Moderate to low intentions in STEM were also seen for the fourth cluster, characterized as somewhat high motivation, and high success and caring profile. Only when students had a high motivation profile did they report high intentions to pursue STEM. This finding suggests that consideration of multiple forms of motivation is important to understanding the trajectories of students within STEM. Furthermore, it demonstrates the usefulness and feasibility of quantitatively assessing differential impacts of multiple forms of motivation on future STEM intentions.

A second limitation comes from the lack of longitudinal studies within this review that extended beyond a single year. Many of the articles were coded as interventions in which new teaching and/or learning strategies were introduced to the population and their impact on motivational outcomes were determined. To assess the long-term effects of interventions, longitudinal research is necessary. In the short term, strategies such as providing partnerships, improving training, and utilizing supportive pedagogical techniques improved motivation (e.g. Scogin & Stuessy 2015; Dublin et al., 2014). Other circumstances, such as failing to realize the importance of family values, stereotyping, social comparison, and failure to support individual student needs, decreased motivation. Some, such as incorporating drama education to improve student competency, had no effect at all (Swanson, 2017). What remains unclear, however, is how motivation in rural contexts changes over time, and how this contributes to the gap seen in rural STEM representation.

Assessing rural students' motivation for STEM only within the context of a single school year or semester may not capture the ways in which shifts in contexts shape students' trajectories in STEM over time. For example, Saw and Agger (2021) found that although similar levels of interest in STEM fields for rural and suburban students are measured at the onset of high school, interest levels become statistically different by 11^{th} grade. Although they suggest lack of STEM learning opportunities as a primary contributor to the changes in college STEM aspirations for rural students, it is unclear what is changing. It is evident from this review that motivational constructs apart from interest such as student's competence, value, belonging, and identity all contribute to their desires to pursue STEM. Thus, while lack of STEM learning opportunities may play a role in the decline in interest in pursuing STEM fields, other factors may also be at work. These factors cannot be determined without assessing interest, along with other forms of motivation, across more time points. Thus, simply focusing on the lack of STEM learning opportunities does not provide the full story. The influence of STEM learning opportunities cannot be fully understood without also assessing how and when motivation for STEM is changing across time.

Limitations in What Motivation Has Been Studied

While many different types of motivation were represented in the studies, emotional engagement was the most common category by far. Measurement of emotional engagement typically occurred immediately following an intervention, and the affective responses to interventions were generally positive, increasing liking, enjoyment, and interest. According to Hidi and Renninger's (2006) four-phase model of interest development, this type of interest is situational. It is triggered by the environment and maintained by emphasizing the value of the topic to promote further interest. The review of the papers suggests that interest could be increased and maintained by making the outcomes of the intervention personally relevant to the needs of rural communities thereby increasing their value. To capture this shift from situational to maintained individual interest, however, engagement with materials would need to be measured across time and outside of the original context in which they occurred. Thus, the lack of longitudinal studies in general, or longitudinal studies which measured outcomes outside of the context of a single school year, makes measurement of shifts in engagement and the lasting impact of engagement interventions impossible. While this limitation does not negate the potential of these interventions to provide the necessary environment in which to initiate individual's interest and persistence in STEM, they do emphasize the need for longitudinal measurements to determine sustained engagement, development of internal drives, and long-term motivation for STEM. Enjoyment of STEM activities is important, but not conclusive in its prediction of long-term STEM outcomes.

Limitations in Applying Motivation Research

In exploring themes in the ways in which motivation is applied to support STEM education in rural contexts, I found that certain types of motivation were siloed within teacher or student populations (Table 3). For example, many studies focused on student identity as an important factor influencing STEM outcomes, yet teacher identity, or more specifically, the ways in which to support identity as a rural STEM teacher, was understudied. Like with students, teacher identity is both personal, encompassing factors such as race, culture background, etc., as well as professional (Beauchamp & Thomas, 2009). Professional identity in STEM would include self-concept of factors such as content knowledge, pedagogical approaches, and position within school environments. Recognition and support of teacher identity has been recognized as an important component of maintaining teacher's health and teaching confidence (Hong, Greene

& Lowry, 2017) as well as retention in STEM fields (Hong & Greene, 2011). This is particularly true for new educators who may experience more challenges to identity as they figure out their place within the field. The articles found in this review which did focus on teacher identity identified some challenges and potential solutions specific for rural STEM educators. For example, teaching outside of the STEM field in which they were trained was found to lower STEM teaching identity, and teaching communities were suggested as a potential solution to counteract this problem. However, none of the articles within the review explored the impact of providing supports on teaching identity or the impact that supporting rural teacher identity in STEM has on factors such as rural STEM teacher attrition and provision of STEM learning opportunities for students. Thus, rural STEM teacher identity represents another avenue of exploration for addressing the gap in rural STEM representation.

Conversely, most papers that measured competency focused on teacher competency for various instructional practices while few explored rural student's competencies in STEM fields. Those that did demonstrated mixed results. Outside of rural populations, higher self-efficacy in STEM has been positively associated with student outcomes such as retention, persistence, and performance in a variety of STEM fields (e.g., Lin, Lee & Snyder, 2018, Halim, Rahman, & Ramli, 2018; Mau & Li, 2018). Many interventions have also been developed to improve student self-efficacy in STEM (e.g. Falco & Summers, 2019; Roche & Manzi, 2019; Samsudin et al., 2020). This demonstrates the potential of self-efficacy interventions to improve STEM outcomes for rural students. However, these studies have not been conducted within rural contexts, and outcomes of interventions have been demonstrated to be context dependent (Rosenzweig, Song, & Clark, 2022). Competency-supporting factors such as vicarious learning opportunities and mastery experiences (Bandura, 1997) may be influenced by the differential access of rural communities to resources such as STEM role models and STEM learning opportunities as well as stereotyping of rural populations. Thus, future research to promote student competency in STEM can be drawn from current literature, however, they must be applied to rural environments to ascertain the fidelity of the results across contexts.

Implications and Future Directions

A systematic review was used to better understand the extent to which motivation has been explicitly studied in rural STEM contexts by first exploring whose motivation has been measured in rural contexts and how it has been measured. While many of the articles failed to report the ethnic distribution of the participants, those that did were biased towards Western, English-speaking countries and primarily white populations. Studies within this review also primarily focused on K-12 settings while limited research was conducted on pre-service teachers or post-secondary teachers and students. Despite the reciprocal nature between student and teacher motivation, student motivational outcomes were measured twice as often as teacher motivational outcomes. Next, how motivational research has been conducted was explored. Qualitative, quantitative, and mixed methods were represented approximately evenly across the articles. While qualitative studies often included multiple forms of motivation, more quantitative research highlighting the influence of multiple forms of motivation on STEM outcomes is needed. Furthermore, many of the articles described educational interventions in which new teaching and learning strategies were introduced to the population and the influence on motivation was determined. However, the long-term impact of these interventions is limited due to the lack of longitudinal studies to measure motivational outcomes across times and contexts. Thus, future research should focus on the nuances of different rural contexts and populations, the impact of intersectionality, and longitudinal measurements of multiple forms of motivation.

The second research question focused on what motivation had been studied in rural STEM contexts. While each of the six broad categories utilized for coding review articles were represented in the literature, they varied in their distribution. Engagement was represented the most, while belonging was represented the least. For teachers specifically, competence was measured just as often as engagement. While engagement can serve as an important pre-cursor to long-term motivation in STEM, its initiation is considered context dependent. Thus, the emphasis of engagement in the literature may be a byproduct of the fact that so many of the articles contained interventions in which students and teachers were introduced to novel experiences. While this does not negate the impact of these studies, it again calls to the need for measurement of multiple forms of motivation and longitudinal research.

Finally, a critical approach was used to discuss ways in which motivation has been applied in rural contexts to support STEM education. These included three primary strategies: partnerships to promote engagement and value for STEM learning, incorporation of culturally relevant and place-based pedagogies to support STEM identity and belonging, and rural-focused training to support STEM competency. Through this review, it was found that some strategies are applied preferentially to specific populations in rural communities. These include student STEM identity studies and teacher competency studies. However, research evidence from other populations outside of rural contexts suggest the need for extending the application of these strategies. In other words, identifying ways of supporting student competence and teacher identity can also improve their overall STEM outcomes.

With rural students representing one-fifth of the overall population of students present in the United States, their potential contributions to the diversity and labor demands necessary to drive STEM fields cannot continue to be understudied, undervalued, or ignored. Instead, it is necessary to better understand ways in which to support rural students in STEM in order to increase their access and opportunities within STEM fields. Because of the necessity of motivation in task inhiation and persistence, this includes supporting teacher's and student's motivation for providing and engaging in STEM learning opportunities. Contrary to the deficit narratives regarding rural STEM education and stereotyping against rural individuals in STEM, multiple ways of supporting motivation for STEM were found to already exist within the literature of STEM motivation in rural contexts. However, many additional ways of supporting motivation for STEM in rural contexts utilizing the various theories of motivation research remain to be explored.

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Tables and Figures

Figure 1

Multistep Screening Process for Article Eligibility

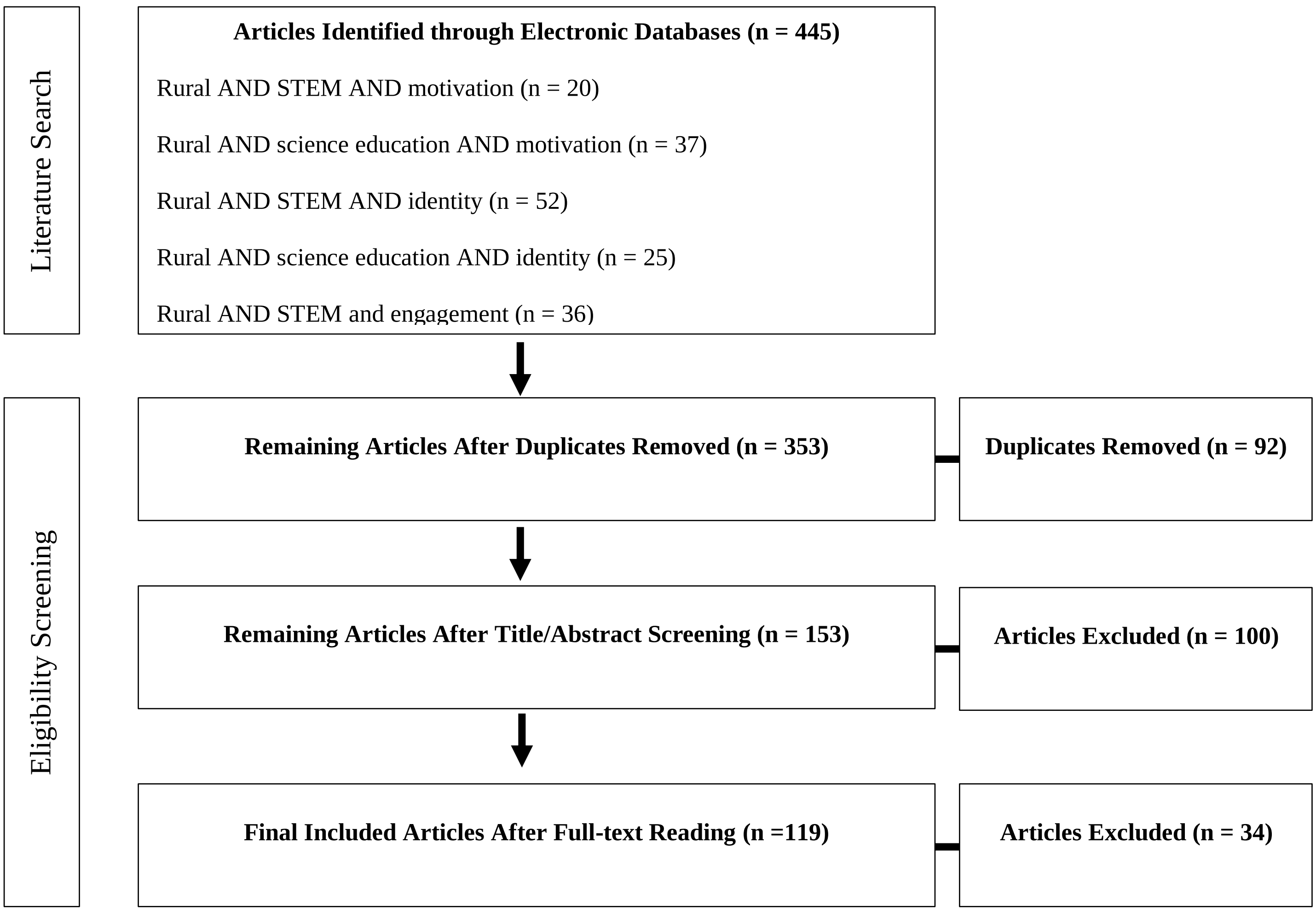

Table 1
Demographic and Methodological Codebook

Characteristic	Code
Rural Definition/ Description	Yes/No
Population	Pre-School Students Elementary Students Middle-School Students High School Students Post-Secondary Students Pre-Service Teachers Pre-School Teachers Elementary Teachers Middle School Teachers High School Teachers Post-Secondary Teachers Other Educators
Race/Ethnicity	American Indian or Alaska Native Asian American or Pacific Islander Black or African American White or European American Hispanic or Latino/a Multiracial Not given
Research Focus	Rural-only population a. Non-convenience sample b. Convenience sample Mixed population
Location	United States/Canada Europe Africa Asia South America/Latin America/Central America Australia/Oceania
Method	Qualitative Quantitative Mixed-Methods
Intervention	Yes/No Definition: Introduction of new teaching or learning strategies or materials designed to influence motivation
Longitudinal Design	Yes/No Definition: A single variable/ set of variables measured across multiple time points either within the same research participant or different research participants. A minimum of 1 week must occur between repeated measures.

Table 2

Motivational Themes Codebook

Theme	Subcode
General Motivation *encouragement/discouragement towards action.*	**Intrinsic Motivation** *Internal drives associated with behavior* **Extrinsic Motivation** *External drives associated with behavior* **Undifferentiated Motivation** *Motivation not specified as intrinsic or extrinsic* *Ex. The students were motivated to learn science.*
Identity *How one views oneself*	**STEM Identity** *Ability to fit in in STEM environment or be recognized as a scientist by self or others. Includes recognition of STEM teacher identity* **Non-STEM Identity** *Component of identity not directly related to STEM. Includes identity as teacher/professional, racial/ethnic identity, gender identity, rural identity, etc.* **Aspirations in STEM** *Plans to pursue STEM career,, take STEM courses, teach STEM, etc.*
Engagement *Positive/negative interactions with materials*	**Behavioral Engagement** *Observable act of participants learning or teaching. Includes conducting experiments, joining extra-curricular activities, preparing lessons, online logins, etc.* **Cognitive Engagement** *Willingness to tackle mastery of topics/Efforts put into* learning. *Includes Discussion of content, attempting difficult problems.etc.* **Emotional Engagement/Interest** *Affective reactions to school environment, Includes interest, enjoyment, boredom, etc.* **Undifferentiated Engagement** *Engagement not specified as behavioral, cognitive, or emotional* *Ex. The teacher reported that the students were more engaged in class.*

Competence Beliefs *Belief that one can/cannot perform a task*	**Self-Efficacy** *Individual beliefs regarding success/failure at a specific task. Includes final score on an exam, ability to complete a problem, etc.* **Perceived Competence** *How skilled an individual perceives them to be in an area [past oriented]* **Expectancy for Success** *Individual beliefs regarding success/failure at a future task* **Undifferentiated Competence** *Competence not specified as self-efficacy, perceived competence, or expectancy for success* *Ex. Confidence in mathematics*
Value *Importance associated with a task*	**Utility value** *Task is perceived as useful for one's current or future goals* **Attainment value** *Task is perceived as personally important* **Undifferentiated Value** *Value not specified as utility or attainment value* *Ex. The students and teachers found value in the activity*
Belonging *Sense of fitting in, acceptance, inclusion*	

Note: All codes were either given as present (1) or not present (0).

Figure 2

Ethnic Distribution of Studies Conducted in the United States

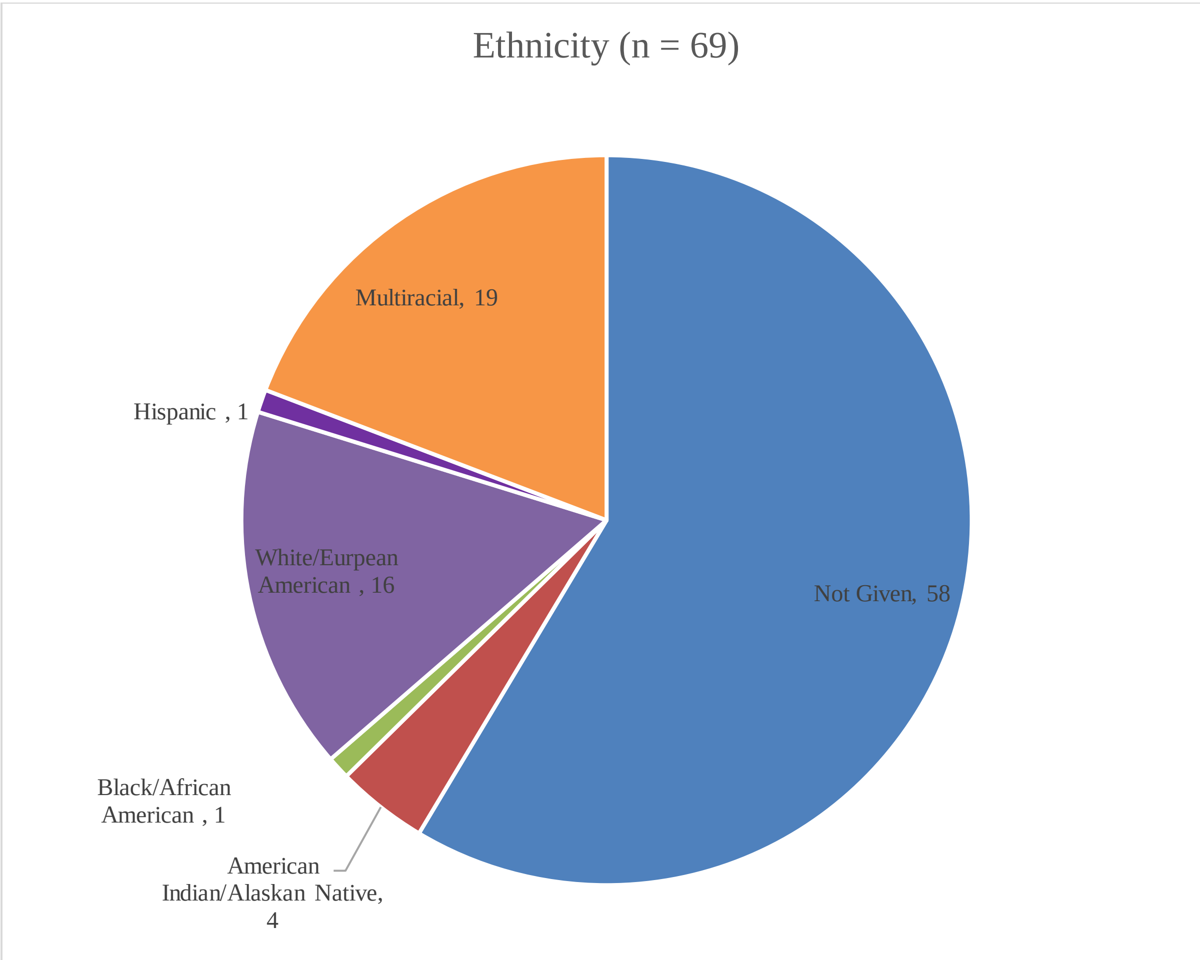

Figure 3

Number of papers which measured motivation in students (A) and teachers (B) by grade level.

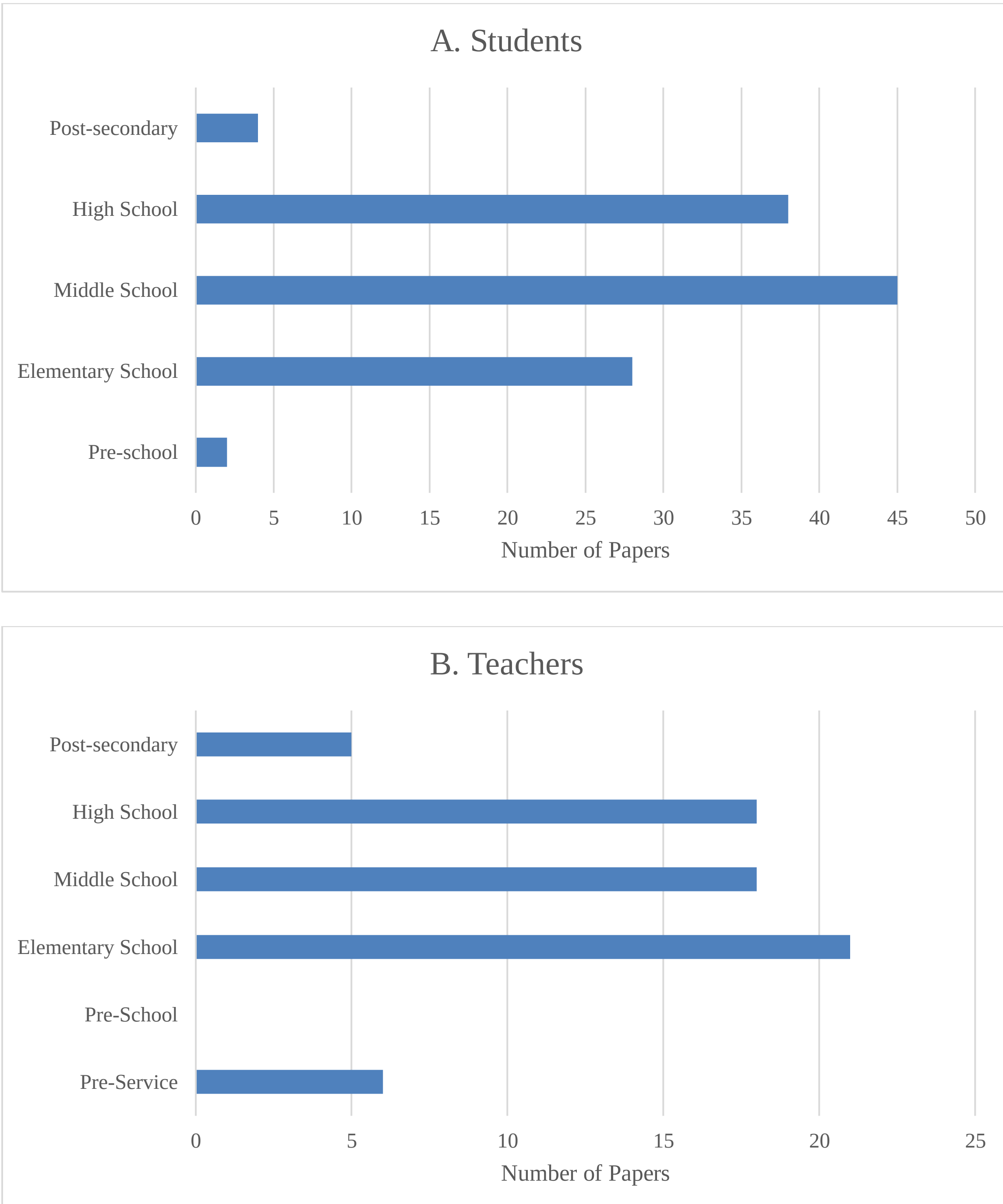

Table 3

Distribution of Motivational Theme and Subcodes. Note: Totals reflect the number of papers which measured each construct. Papers could measure multiple constructs.

	Total	**Students**	**Teachers**
General Motivation	26	15	11
Intrinsic Motivation	15	8	7
Extrinsic Motivation	11	9	2
Undifferentiated Motivation	6	4	2
Identity	38	30	8
STEM Identity	9	7	2
Non-STEM Identity	14	10	4
Aspirations in STEM	26	24	2
Engagement	102	76	26
Behavioral Engagement	47	34	13
Cognitive Engagement	34	30	4
Emotional Engagement/Interest	82	65	17
Undifferentiated Engagement	4	3	1
Competence Beliefs	55	30	25
Self-Efficacy	32	14	18
Perceived Competence	5	5	0
Expectancy for Success	7	2	5
Undifferentiated Competence	17	10	7

Value	46	37	9
Utility Value	38	33	5
Attainment Value	8	6	2
Undifferentiated Value	6	4	2
Belonging	12	7	5