Motivation in the Science Classroom: Through a Lens of Equity and Social Justice

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Motivation and Science Learning

The degree of student motivation in a particular content area is often driven by the instructional strategies that teachers implement in the classroom. Oftentimes science teachers discuss lack of motivation in the science classroom as a concern particularly relative to participation from traditionally underrepresented and marginalized groups. Students that are not motivated are disengaged and often disenfranchised with their science learning experiences which often results in their underrepresentation in the STEM (science, technology, engineering, and mathematics) pipeline on the college level and beyond. Historically, there has been a "leak in the science" pipeline particularly relative to the participation of females and other traditionally underrepresented groups (e.g., African Americans, Latinos/as, and American Indians).

Moreover, because many science topics are often taught from a traditionally Westernized perspective and teachers rarely have the skills from teacher preparation programs to teach science from a culturally relevant perspective, students from traditionally underrepresented groups are discouraged from persisting in the science pipeline (or viewing themselves as scientists). This underrepresentation results in inequities and perpetuates the culture of hegemony and status quo that exist in the STEM fields. Furthermore, the lack of role models for students of color and women in higher education STEM areas is an issue of equity and social justice. When science is taught in a manner that does not emphasize how it connects to the student's daily life, this further marginalizes students making it easy to lose interest and

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develop negative attitudes towards science. One key factor for encouraging students to persist in the sciences is to design science lessons that are culturally relevant and challenge inequities in the way science is presented, while motivating students interest towards participation in the STEM pipeline.

This chapter based on research in motivational theory and achievement motivation aims to address how teachers can promote student interest in science. Moreover this chapter provides insights into how teachers can motivate their students to achieve in the science classroom through a lens of equity and social justice. Specifically, since many teachers express dissatisfaction with their students' lack of motivation, this chapter attempts to provide insights and strategies to help them focus on transforming their classroom environments to better motivate students and engage more students in the science pipeline.

What Is Motivation?

Although there are a number of motivational theories and definitions of motivation in the literature, the consensus is that motivation is an internal condition or state that serves to drive or direct an individual towards completing a task or goal (Cavas, 2011). According to Palmer (2005), motivation can in essence be applied to any process that triggers learning and maintains the intended learning behavior. Motivation in educational research is a broad and complex topic relative to teaching and learning, and to those outside the field of motivational research, this topic can seem fragmented (Murphy & Alexander, 2000) and overwhelming. However, motivation is one of the best predictors of an individual's persistence for the long term in a particular area of interest (e.g., educational interest) (Harackiewicz, Barron, & Elliot, 1998; Tauer & Harackiewicz, 2004). According to Ormrod (2008), as cited in Lei (2010), motivation can be characterized as an internal state that enhances or arouses the learner, guiding her/him in a particular direction and keeping them engaged, towards completion of a task.

Over the past few decades, research on motivation has flourished and more is known about what motivates students (Guvercin, Tekkaya & Sungur, 2010; Wigfield, 1997) on both the precollege level and the college level. Moreover, the extent to which and whether or not a student engages in a challenging task is often determined by her/his degree of motivation (Lei, 2010). Theories that drive research on motivation are typically centered on motivation being defined as the "energization" and "direction of behavior" (Pintrich, 2003). Essentially theories in motivation try to explain what actually drives an individual towards a specific activity or task (Pintrich, 2003). In order for knowledge construction to occur, the learner must first be motivated to put forth effort in completing a task (Palmer, 2005). The Expectancy-Value theory of motivation is used as a theoretical framework for much of the research in motivation (Wigfield & Eccles, 2000; Weinberg, Basile, & Albright, 2011). The essence of Expectancy-Value theory outlines student expectations for success and the value they place on completing a set or assigned task (Wigfield &

Eccles, 2000; Weinberg et al., 2011). Moreover, a student is more likely to engage and show interest in a particular topic or activity if they perceive value in completing the task (Wigfield & Eccles, 2002 as cited in Weinberg et al., 2011).

Motivation to learn, motivation to learn according to Brophy (1998) is the tendency to see an academic task or activity as meaningful towards a specific academic goal or benefit. In science, the degree of student motivation is often determined by the level of engagement the student has in the science-related activity in an effort to better understand the content (Lee & Brophy, 1996).

Motivation is an important factor in the science classroom because it essentially promotes the construction of knowledge and conceptual understanding of science concepts (Cavas, 2011). Moreover, being motivated to learn science is beneficial to students in the early school years as it inspires them to become future scientists (Bryan, Glynn, & Kittleson, 2011). It is also important for students to be motivated in science as it promotes scientific literacy for all students (Bryan et al., 2011). Consequently, if science teacher educators are to prepare preservice teachers for an increasingly diverse classroom, it is paramount that strategies for motivating students are clearly delineated to help promote scientific literacy for all students while increasing the scientific pool of applicants in a global society.

There are a number of major reforms in science education geared towards increasing the motivation of students intrinsically and extrinsically (NRC, 1996, 2012). Whether or not students elect to learn a challenging task or engage in science can often be determined by motivation (Ormrod, 2008 as cited in Lei, 2010). Students may be interested in science because of external factors (i.e., parents, teacher praise, grades, rewards) or internal factors (i.e., desire to attend college, or self-efficacy). Motivation is typically referred to in two major categories which include either intrinsic or extrinsic (Lei, 2010). There has often been much debate as to which is the preferred strategy for motivating students.

Intrinsic motivation is defined as the internal satisfaction a student feels about completing a particular task (Lei, 2010) and students typically complete an activity for enjoyment (Brewer & Burgess, 2005). Extrinsic motivation is characterized by the use of external rewards or incentives (often in the form of grades) to stimulate a student to complete a task (Brewer & Burgess, 2005). There is also a third category called "motivation to learn" which addresses the overall benefit or degree of meaningfulness of the academic task (Marshall, 1987) There are numerous pros and cons for intrinsic and extrinsic motivation. However, according to research on intrinsic motivation, it is important that students that are intrinsically motivated are encouraged not to lose track and become "too consumed" in completing a task (Lei, 2010).

Another one of the drawbacks of intrinsic motivation is when students experience tunnel vision and do not complete other essential tasks (Ormrod, 2008 as cited in Lei, 2010) which can impact their achievement and persistence in the other tasks. However, intrinsically motivated students learn better and tend to be more creative than students that are extrinsically motivated (Niemiec & Ryan, 2009). On the other hand, the extrinsically motivated students typically complete a task based on grades, or other tangible rewards that can represent they succeeded in learning a task (Lei, 2010). The benefit of this type of motivation is that students will take initiative to complete the task, however, the challenge for teachers is that they must ensure that the incentive is something that is valuable to the student otherwise they will lose interest in completing the task (Covington, 2000 as cited in Lei, 2010). Overall, research by Areepattamannil, Freeman, and Klinger (2011) demonstrates that learning for the enjoyment of science (intrinsic motivation) plays a very important role in students learning in the science classroom. Subsequently, it is important to promote students' intrinsic motivation to enhance their scientific literacy and thinking processes in science (Areepattamannil et al., 2011).

Motivation and Participation in Science

There are a number of factors that impact the motivation and participation of students from underrepresented groups in the sciences. Some of these variables include ability level, attitude, self-perception, socioeconomics, peer and parental influence, school factors, and home factors (Singh, Granville, & Dika, 2002). Research by Markowitz (2004) has even demonstrated the positive impact of outreach programs in biomedical research on precollege students interest in participating in science as well as enhancing the desire to pursue careers in science. Oftentimes students from marginalized and underrepresented groups lack motivation because of the curriculum and low expectations from teachers encountered in the science classroom. Recent studies demonstrate how interventions that integrate more academic rigor (Ruby, 2006) and inquiry-based instruction (Pickens & Eick, 2009) can motivate students in science. Oakes (1985, 1990a, b) describes the following factors as specifically impacting the participation of females and people of color from underrepresented groups in science: (a) access to resources, (b) cultural barriers, (c) socioeconomic status, (d) interest, and (e) lack of encouragement.

Decades after research by Butler-Kahle (1992) research by Norman, Ault, Bentz, and Meskimen (2001) examined the historical and sociocultural implications that impact science participation relative to the Black/White achievement gap. For the most part, a large number of students from traditionally underrepresented groups typically attend schools in urban settings where there is often a lack of resources in comparison to Whites that attend schools in more suburban areas (Norman et al., 2001). Norman et al. posit that throughout history there were various racial/ethnic groups (e.g., Polish, Jewish, Italian) that were immigrants (though voluntary) and relegated to the bottom of the social caste system in the United States. However, as time passed, these immigrant groups were able to assimilate into the mainstream culture in the United States. Subsequently, they moved out of the more impoverished urban areas and achievement differences between the new immigrants and European Americans diminished to the point where the differences in achievement were almost nonexistent (Norman et al.). This demonstrates that there are also sociocultural in addition to ethnic/racial factors that impact student achievement. Consequently, since today many African Americans and Latino/as are situated in more urban and high-poverty areas, they still maintain a relatively low status in society. This is not to say that students from high-poverty areas cannot and do not achieve at high levels, but that living in such areas has an impact on access to resources, quality of education, exposure to a challenging curriculum, and additional educational opportunities that many students in suburban areas are afforded. As a result, the stigma of inferiority, and a type of bigotry that translates into low expectations, limits access to resources that promote interest, positive attitudes, and achievement in science.

Relative to females, and students from traditionally underrepresented and underserved populations sociocultural factors (Butler-Kahle, 1982; Butler-Kahle & Lakes, 2003) also impact their participation in science, as they are often subjected to stereotypes that subsequently have the same lasting impact on self-concept in science. Although there are a number of research studies on motivation and achievement in science, there is still little research on methods for motivating and encouraging students particularly from traditionally underrepresented groups to achieve and persist in science (Brown, 2000; Pickens & Eick, 2009).

One reason that motivation is of interest to science teachers educators is because attitudes and motivation towards school as a whole are predictors of high school adaptation and performance (Murdock, Anderman, & Hodge, 2000). Research by Hill, Atwater, and Wiggins (1995) on seventh graders in life science in urban classrooms suggested that students who possess positive attitudes towards science were more likely to take more science classes. In addition, when these students were asked about their career goals, the students with positive or undecided attitudes in science were more likely to say they would choose science careers (Hill et al., 1995). Since it is clear that motivation is critical to participation, attitude, and interest in science, it is also important to examine the role that teachers and pedagogical strategies play on motivating students in the science classroom. Simply put, science teachers play a significant role in their students' achievement and how they teach can have a profound impact on student motivation in the science classroom. Essentially, because teachers often teach the way they were taught (typically in a traditional and didactic manner), they fail to integrate more culturally relevant pedagogy into their lessons especially for those teaching in high-poverty school districts where there are larger populations of traditionally underrepresented and marginalized students. Interest and affinity towards science can have a significant impact on student motivation and without interest in science (especially during the early grades) students from underrepresented groups will not have opportunities to persist in science to pursue STEM careers.

Teachers can have profound impact on a student's motivation to learn (Blumenfeld & Meece, 1987). This being said, it is essential to encourage and promote positive attitudes towards science for students from underrepresented groups, especially if we are to increase and diversify the scientific pool and enhance the participation of underrepresented groups (e.g., African American, Latinos/as, and females) in STEM fields. Additional research in science education has described not only attitudes as impacting participation or interest in science but motivation, achievement styles, and other affective variables (Atwater & Simpson, 1984).

Motivation and Equity in the Science Classroom

Motivation plays a critical role in achievement and significantly influences learning, as well (Ames, 1992). Though reform efforts in science education address equity in STEM education, the reality is that there is little equity relative to access and opportunities for students from traditionally underrepresented groups in STEM areas. The National Assessment of Education Progress delineated average science scores of students for age levels 9, 13, and 17 years old have increased minimally over the past three decades (Campbell, Hombo, & Mazzeo, 2000).

It is well known that teacher effectiveness is directly correlated with increased science achievement for students. However, unfortunately many of the lower-achieving students (particularly students from high-poverty, rural, and urban areas) typically encounter the least effective teachers (Lynch, Kuipers, Pyke, & Szesze, 2005). Oftentimes the most ill-prepared teachers, who may lack certification are more likely to have teaching assignments outside of their content area teaching outside of their content area, and are assigned to teach in the most challenging school districts and lowest-performing school systems. This situation only contributes to an unfortunate term often referred to by researchers a "pedagogy of poverty," and even teachers that have learned about the benefits of hands-on inquiry-based learning in their teacher preparation programs revert back to the more traditional teaching strategies. Consequently, many teachers in the low-performing schools kick into "survival mode," and expectations are lowered for students as many teachers who are not prepared for the challenges of a beginning teacher revert back to what is familiar (i.e., worksheets, lectures). Attitudes are also extremely important during the middle school years as they tend to become more negative, and self-concept and perceptions of competence tend to decline around this time (Anderman & Maehr, 1994). Moreover, research by Weinburgh (1995) determined that positive attitudes in science can lead to high achievement. Research also indicated that this was especially so for the low performing girls in science (Weinburgh, 1995).

Science career choice and goals for attainment are often attributed to early choices students make since there are specific "gate-keeping" science and mathematics courses that students must take in the junior high school and early high school years to continue in a career trajectory in science (Lavigne, Vallerand, & Miquelon, 2007). Research by Bryan et al. (2011) recommend that to promote motivation for students to learn science, researchers must examine ways to increase students' participation in AP courses in high school, as well as investigate and assess students' motivation to learn science in high school science courses. There also needs to be more emphasis on role models to interest students in science careers (Bryan et al.). In addition, for females, science participation is often attributed to achievement and subsequent enrollment in math courses, as well (Butler-Kahle & Lakes, 2003). If we go back even further than the impact of middle and high school science experiences on science career choices, we can closely examine the elementary years. Maximizing the number of quality science experiences during the early grades can have a positive impact on attitude, interest, and motivation in the sciences.

Motivation has a direct impact on academic achievement and promotes interest and engagement in completing academic tasks to further learning (Singh, Granville, & Dika, 2002). As a result, it is critical that factors that motivate students from underrepresented groups to participate in science be clearly delineated so that teachers and teacher educators can address these factors in their science and science education classrooms to promote equity. Subsequently, the problem of the pervasive achievement gap in science has been the center of research that addresses equity and diversity in over the past few decades (Atwater, 2000; National Science Foundation, 1994, 1998, 2000, 2012). Unfortunately, the state of low achievement in science among students from underrepresented groups who are often primarily African American or Latino/a pose significant barriers to their persistence in science. In an increasingly technological society, it is important to address the long-term, adverse impact that limiting access to STEM careers for any student will have long-term, adverse impacts on the national and global economy. Studies on the achievement gap in science has specifically highlighted the gap relative to Black students and White students (Braun, Chapman, & Vezzu, 2010; Norman et al., 2001; Simms, 2012). Additional studies investigate the science achievement gap relative to socioeconomic status in urban or rural areas (Lee & Madyun, 2009; Pickens & Eick, 2009; Ruby, 2006) or track placement (Oakes, 1985, 1990a, b; Pickens & Eick, 2009).

Self-Efficacy, Self-Concept, and Attitude: Motivation in Science

A vast amount of research in counseling psychology has examined the role of self-efficacy and self-concept in predicting student career goals and aspirations (Gainor & Lent, 1998). Social cognitive theory asserts that an individual's career aspirations are attributed to their self-efficacy and ability (Nauta, Epperson, & Kahn, 1998). Bandura (1977) describes self-efficacy as an individual's personal judgment regarding one's ability to perform a specific behavior or task or their self-perceived confidence to be successful in a science-related task, activity, or course (Britner & Pajares, 2001, 2006). Self-concept is defined as an individuals' perception of their academic ability (Bong & Skaalvik, 2003 as cited in Areepattamannil et al., 2011) or how they view themselves (i.e., I see myself as a good student in science). Furthermore, confidence in the content affects student motivation and achievement (Mamlok-Naaman, 2011). Moreover, according to Nelson & Debacker (2008) positive peer relationships and the extent to which students feel valued and accepted also positively impacts achievement motivation. This kind of information is critical relative to science teaching and learning (Arzi, Ben-Zvi, & Ganie as cited in Mamlok-Naaman, 2011). Furthermore, when students are both interested in a science concept and understand it, they tend to have better attitudes towards science as opposed to students that have difficulty with the concepts (Mamlok-Naaman, 2011). Several researchers assert that student motivation in science can increase or decrease how a student learns, or if they want to learn a concept (Barila and Beet, 1999; Fairbrother, 2000; Pintrich, Marx, & Boyle, 1993 as cited in Mamlok-Naaman, 2011).

There is a significant amount of research that focuses on the obvious relationship between achievement and academic motivation both in the United States and abroad (Ames, 1992; Bryan et al., 2011; Gottfried, 1985; Nolen, 2003; Oliver & Simpson, 1988). Studies have also found and discovered a correlation between achievement in science and student attitudes (Butler-Kahle, 1982; Sorge, 2007 as cited in Milner, Templin, & Czerniak, 2010). Over the past years, there has been a steady decline in student academic motivation and motivation can be attributed to both school-related and home-related factors (Gottfried, Marcoulides, Gottfried, & Oliver, 2009). Student attitude and interest in science play a significant role in motivation, and interest in science often results in increased attention during formal instruction as well as participation in science-related activities or courses (Farenga & Joyce, 1999; Farmer, Waldrop, & Rotella, 1999; Germann, 1988 as cited in Farmer, Waldrop, & Rotella, 1999; Marcowitz, 2004 as cited in Farmer, Waldrop, & Rotella, 1999).

This being said, it is imperative that science is taught so that students from traditionally underrepresented groups see that science is a topic in which they can be successful. Teachers must make it clear that they hold high expectations for all of their students and encourage them to engage in complex learning of abstract science topics that challenge students. Furthermore motivation has a direct impact on student achievement, engagement, and the process of conceptual change (Wentzel & Wigfield, 2007; Wigfield & Wentzel, 2007). Motivational factors play a significant role in future career goals and plans of individuals relative to self-efficacy and self-concept (Singh, Granville, & Dika, 2002) and these factors especially play a critical role in motivating students from traditionally underrepresented groups in STEM areas (Wentzel & Wigfield, 2007; Wigfield & Wentzel, 2007).

Strategies that Enhance Motivation in the Science Classroom

Factors that have been examined relative to motivation look at the impact of attitude, achievement, teaching strategies, and professional development. In order to continue investigating strategies for making the science pipeline more inclusive, researchers need to continue to focus on how high achievement and interest in science and mathematics are known predictors or indicators of students' persistence in the science and mathematics pipeline (Powell, 1990; Thomas, 1986), as well as gateways to careers and degrees in science.

Research by Brewer and Burgess (2005) on the college classroom showed the following results that could be transferable to the precollege setting which include personal qualities and good classroom management. On the secondary level, research demonstrates inquiry-based and interactive instruction (Pickens & Eick, 2009) as a primary motivator in the science classroom. Much of the research on motivational strategies is embedded in what we already know about teaching and learning. More specifically, Williams and Williams (2012) posit that there are five keys that teachers can implement to improve student motivation. These include the teacher, student, pedagogy/methods, environment, and content. Listed below is a synopsis of five primary motivation factors according to Williams and Williams (2012). They refer to these factors as the five keys ingredients that have an impact on motivating students in the classroom (Williams & Williams, 2012).

1. Teacher should have a good mastery of content, qualifications in content area/ pedagogical content knowledge, and motivational level (Williams & Williams, 2012)
2. Content should be accurate and relevant (Williams & Williams, 2012)
3. Pedagogical approach/methods should be both experiential and engaging (Williams & Williams, 2012)
4. Environment should be one of quality and conducive for motivating and learning, available, and accessible (Williams & Williams, 2012)
5. Students should not be in a traditional mode of receiver of knowledge but they should come to class motivated whether intrinsically or extrinsically (Williams & Williams, 2012)

Certainly, this list is not mutually exclusive and there are a number of other factors; however, these are considered critical in fostering an environment that promotes learning and achievement towards motivating students. In addition, other aspects of pedagogy or methods relative to motivating were the teachers' enthusiasm, addressing learning styles, and setting goals and objectives.

According to Pickens and Eick (2009), students' benefited from a class that fostered a positive learning environment and high teacher expectations a result of the use of hands-on instruction and interactive teaching strategies. Milner et al. (2010) describe the structure of the learning environment as a key motivating factor for students and use a constructivist classroom context. Essentially their research addressed the impact of incorporating a life science laboratory into the classroom to increase motivation through constructivist teaching and learning practices. As a result of the implementation of the life science laboratories, students were able to investigate science in a more "authentic" environment (Milner et al.). Students interviewed revealed that they experienced science in more relevant ways, which allowed them to apply what they learned to the traditional classroom and the life science laboratories enhanced the students constructivist learning and engaging them in science via an inquiry-based continuum (Milner et al.).

Additional research by Nolen (2003) also reported that the learning environment was a significant predictor of satisfaction and achievement in science particularly when the teacher promoted independent thinking and student understanding. The use of technology and media in the science classroom has also been shown to be effective in motivating students (Liu, Horton, Olmanson, & Toprac, 2011). Researchers in this study implemented a media approach through problem-based learning (PBL) for the middle school science classroom and results indicated that students' knowledge on the content covered and motivation increased (Liu et al., 2011). Moreover, students expressed that they enjoyed the activities and results indicated positive relationships between motivation scores and science content knowledge (Liu et al. 2011).

One key factor in motivating students in science looks at how teachers design their curriculum and structure their lessons to be more relevant to students' daily lives (Bryan et al., 2011). In addition, students emphasized that they are motivated by good grades, teacher competence in content area, teacher enthusiasm, teachers caring ethic and hands-on activities (Bryan et al.). Moreover, students prefer less PowerPoint-oriented lectures and more inquiry, autonomy, field trips, labs, collaboration in class projects, and social interactions in class (Bryan et al.). These are important factors that have been highlighted and provide a platform for teachers and teacher educators to work from in efforts to transform their own classrooms and promote achievement for their students. More specifically, implementation of these strategies is a beginning towards involving more students from underrepresented groups in the STEM areas on both the secondary and post secondary level.

It is paramount for science teacher educators to investigate key motivating factors that encourage and enhance the participation of traditionally underrepresented groups in STEM to promote more equitable representation in the STEM pipeline. Though some believe that there is already equal access to science participation, the reality is that this is not true for many students from culturally diverse backgrounds, females, and individuals with disabilities. It is essential that science teachers and science teacher educators examine their pedagogical strategies and provide enriched science learning experiences that enhance interest, attitudes, and motivation in science. These types of inputs will better level the playing field and promote equity in outcomes relative to who persists in science throughout the middle and high school years and who pursues STEM degrees and STEM careers.

Policy Changes and Motivation in the Science Classroom

The primary impetus for this chapter was to highlight the critical role that teachers can play in motivating their students to learn science. High expectations, inquiry-based lessons, and teacher competence in content area are just a few factors central to motivating students in the sciences, particularly students from traditionally underrepresented and marginalized groups. We live in an increasingly diverse and technologically advancing society and it is paramount that the students in the United States compete relative to technological innovations in this global market. There is a significant amount of "untapped talent and unlimited potential" (Russell, 2005) and teachers need to raise their expectations for students from traditionally underrepresented groups, females, and students with disabilities in STEM so more students are given access to opportunities that promote achievement and interest in science. Educators need to focus on equity relative to the outcomes for students from traditionally marginalized and underrepresented groups in the STEM areas relative to jobs and careers in the STEM areas. Increasing participation of traditionally underrepresented groups also has implications from an economic standpoint since these students will go on to degree programs and careers in the STEM areas which can positively impact their financial stability and economic mobility.

Lastly, I have included several recommendations that I have as a science teacher educator for facilitating teachers in motivating students in science and promoting equity and social justice through their teaching: (a) professional development for teachers to prepare them to teach more culturally relevant curricula, (b) more systemic mentoring programs for beginning teachers in high-poverty school districts in rural and urban areas, (c) collaborative grants between Colleges of Education and school districts that provide opportunities for science teachers and science teacher educators to develop programs to facilitate new teachers with the transition from college into the first years of teaching, and (d) required core courses in equity in teaching. Since new teachers are often overwhelmed with teaching schedules, and more likely to teach out of their content area, there is a need for systemic reform in how teachers are prepared to teach in culturally diverse settings relative to motivating students. Unfortunately, teachers in urban and rural areas (where you would typically find more students from traditionally underrepresented groups) are less likely to implement and design lessons that are relevant to the students' daily lives and provide an enriched science curriculum.

Many schools in high-poverty, rural, or urban areas are less likely to offer advanced science and mathematics courses (essential gatekeepers to careers in the STEM areas); students at schools in these areas are less likely to encounter a rigorous curriculum and enough content background to persist at higher levels in the STEM pipeline. Moreover, a challenging curriculum with support and high expectations from the teachers is also an important factor for motivating students. These aforementioned recommendations for changes are one step in the right direction relative to increasing participation and motivation in students from traditionally underrepresented groups. Until science teacher educators and teachers are better prepared to promote equity and social justice in their science classrooms through instructional strategies that foster motivation in science, many students from groups traditionally marginalized and underrepresented in the STEM areas will never realize their full potential in order to participate in the science pipeline and we will never plug the leak in the STEM pipeline and promote more opportunities and pathways to STEM degrees and careers.

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