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Student learning in science classrooms: What role does motivation play?

Student Learning in Science Classrooms: What Role Does Motivation Play?

One of the major goals of science education today is the attainment of scientific literacy, which includes deeper conceptual understanding of key scientific principles and ideas, the ability to apply scientific knowledge in real-life contexts, as well as the ability to identify problems and conduct scientific inquiry (American Association for the Advancement of Science, 1993; Marx, Blumenfeld, Krajcik, & Soloway, 1997). In examining the antecedents of scientific literacy, one fruitful avenue of research has been the work on student cognition. In particular, this work has underscored the affordances and constraints of prior knowledge in effecting conceptual change. These cognitive models of learning have focused mainly on factors such as encoding, automatization, and metacognitive strategies, which all have been found in laboratory studies to play a critical role in the conceptual change process. However, there is a need to also consider non-cognitive factors such as students' motivational beliefs, especially when examining students' cognitive engagement in academic classrooms (Pintrich, Marx, & Boyle, 1993; Zusho, Pintrich, & Coppola, 2003). Accordingly, the purpose of this chapter is to discuss the value of motivation within science education.

It is important to note that we conceptualize motivation in this chapter more as a process, rather than as a product. Drawing on recent research from social-cognitive and situated perspectives, we stress the multi-dimensional nature of motivation and examine how motivational processes are influenced by classroom contextual factors. In short, we do not consider motivation to be a general trait, with some students more and others less motivated along a general quantitative continuum. Rather, we assume student motivation to be situated and changeable as a function of instruction, tasks, and activities that take place in a classroom.

In considering the relation between motivation and achievement, we propose two general ways in which motivational beliefs can influence positive academic outcomes (Linnenbrink & Pintrich, 2002). First, motivational beliefs can be thought to “mediate” the relation between certain instructional strategies and achievement (see Figure 1a). For example, the implementation of a new inquiry-based curriculum can result in students becoming more interested in science, which ultimately could lead to higher levels of achievement. In short, this view assumes that “good” instruction should lead to more adaptive motivational processes, which should in turn lead to positive academic outcomes (Stipek, 2001).

In contrast to this mediational model, motivational beliefs can also be thought of as “moderators” of instructional effects (see Figure 1b). For example, one could conceive that challenging, more constructivist-based methods of science instruction could be most beneficial to those students who typically like and value science (i.e., those with adaptive motivational profiles), in comparison to those students who are less strategic or who fail to recognize the value of scientific pursuits (i.e., those with maladaptive motivational profiles).

In discussing these two alternative accounts, we focus our analysis on the motivational beliefs of self-efficacy, task value, interest, and achievement goals. Self-efficacy refers to students’ beliefs that they have the resources and confidence to do the tasks in the classroom (Bandura, 1997). Self-efficacy is *not* “self-esteem”, which refers to an undifferentiated affective evaluation of the self. Rather, self-efficacy concerns specific social cognitive judgments of one's capabilities.

Task value beliefs are another important motivational component (Eccles, Wigfield, & Schiefele, 1998). In contrast to the general question of "Am I capable of performing this task?", which is part of self-efficacy beliefs, task value beliefs focus on the general question of "Why do I want to do this task?". In short, task value beliefs concern beliefs about the importance and utility of the subject matter domain, in this case science.

Personal interest refers to an individual's attraction, general liking, and enjoyment of a specific activity or domain (Pintrich & Schunk, 2002). While Eccles and her colleagues (e.g., Eccles et al., 1998) typically consider personal interest (or what they refer to as intrinsic value) under the umbrella of task value beliefs, we believe personal interest to be an important outcome in its own right, especially in light of the marked efforts across various reform efforts to increase students' levels of interest in the sciences (Koller, Baumert, & Schnabel, 2001). For this reason, we have chosen to discuss this motivational belief separately in this paper.

Finally, we consider students' achievement goals as possible mediators or moderators of achievement. Specifically, we examine the role of mastery goals, or goals focused on learning and understanding, as compared to performance goals, or goals focused on outperforming others.

Starting with the next section, we discuss each of these motivational beliefs in detail, beginning with the mediational argument, followed by a consideration of how these beliefs moderate the relation between instruction and achievement. We conclude each section with an examination of how factors such as age, gender, and ethnicity influence these motivational beliefs.

Self-efficacy

As mentioned previously, the construct of self-efficacy includes students' judgments about their capabilities to accomplish certain goals or tasks by their actions in specific situations, as well as their beliefs about their agency in the course (Bandura, 1982, 1986; Pajares, 1997; Schunk, 1991). This approach implies a relatively situational or domain specific construct rather than a global personality trait. In an achievement context, self-efficacy beliefs are primarily influenced by the demands of a task, including skills that are perceived to be necessary for working on the task, students' general perceptions about a subject-domain, as well as prior performance on similar tasks. In turn, self-efficacy beliefs have been found to influence activity choice, as well as students' overall levels of effort and persistence (Bandura, 1997). Generally, researchers have shown that it is more adaptive to have higher efficacy beliefs. For example, students who believe that they are capable of adequately completing a task and have more confidence in their ability to do so typically display the highest levels of academic achievement and also engage in academic behaviors that promote learning (Bandura, 1997; Schunk, 1991; Zusho et al., 2003).

Self-efficacy as Mediator

In terms of a mediational argument, there are a number of ways in which instructional strategies can influence students' self-efficacy beliefs. First, the task itself can have a profound effect on students' perceptions of their capabilities to complete a task. For example, research suggests that students may make lower than usual self-efficacy judgments in the face of challenging activities (Pintrich & Schunk, 2002). As tasks require students to evoke higher-order strategies and integrate a variety of new and learned skills, students may perceive these tasks as extending beyond their present capabilities, therefore engendering feelings of anxiety or perceptions that they are ill-prepared to engage in these tasks.

However, there are ways to offset such potentially detrimental beliefs. For example, without necessarily simplifying the cognitive demands of a task, instructors can help maintain self-efficacy levels by breaking down the activity into more manageable components and by helping students set appropriate goals and encouraging them to think about effective ways to approach the task (Turner et al., 2002). Teachers can also convey the importance to students that science is indeed learnable and that it is possible to increase one's knowledge and skill of science by employing specific strategies (Zusho et al., 2003). For instance, teachers can first demonstrate or model the use of a new strategy, and then continue to monitor and support students' attempts to synthesize concepts by posing questions that gradually increase in level of difficulty, by encouraging students to draw connections among ideas, by clarifying any concepts that remain unclear, and by offering feedback about students' current levels of understanding.

Self-efficacy as Moderator

As new directions in the field of science aim to provide students with opportunities to engage in investigations and solve real world problems, students frequently confront a higher degree of challenge. Specifically, these reform-minded curricular programs often require students to apply a range of strategies and engage in more difficult tasks such as long-term projects and scientific inquiry (Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998). In addition, students are also expected to flexibly employ both domain-general and science-specific skills while developing their conceptual understanding of the science content.

A critical question is posed concerning whether the science instruction advocated by science reforms has a moderating effect on the relation between self-efficacy and student achievement. It is reasonable to expect, for example, that these more challenging instructional practices that engage students in complex investigations may prove most beneficial for those students with higher self-efficacy beliefs. In fact, a moderating relation suggests that it is the interaction between this high self-efficacy and inquiry-based science instruction that enables students to access the most advanced levels of conceptual understanding. Highly efficacious students stand to benefit from these science reforms because they are able to adapt more readily to the challenges introduced through these changes in instruction. In contrast, for those students who are low in self-efficacy, these same science curricula may have no effect or a detrimental effect on student achievement outcomes, such that these students might avoid the task and decrease their subsequent levels of engagement. This question raises important implications for science educators and leaders of these science reform efforts concerning the challenges raised by introducing inquiry methods of teaching, and underscores the importance of maintaining adaptive motivational beliefs.

Individual Differences in Self-efficacy

Perhaps the most striking findings concerning individual differences in self-efficacy beliefs relate to the role of gender. Specifically, gender differences have been noted in students' ratings of their self-efficacy beliefs, as well as their general perceptions of academic competence, with males usually displaying higher levels than females, especially in traditionally male-dominated fields such as science and mathematics (Eccles et al., 1998). Moreover, it has been found that this disparity in the competency ratings of boys and girls becomes even more pronounced following puberty. Researchers have typically accounted for such findings in terms of gender-role stereotyping and gender socialization. Eccles and her colleagues (Eccles et al., 1998) have asserted that while boys may hold higher competency ratings for athletics and mathematics, females often display higher ratings for subjects such as reading, English, and social studies. The magnitude of these differences, however, varies depending on the extent to which boys and girls actually endorse cultural values regarding gender-related superiority in these domains.

Interestingly, despite such gender disparities, investigators have found very little evidence suggesting that males actually outperform females academically (Eisenberg, Martin, & Fabes, 1996). This raises the issue of calibration, that is, the extent to which students' ratings of their motivational beliefs such as self-efficacy, accurately reflect their true level of motivation and achievement as measured by some external, objective standard. Some researchers have argued that males typically overestimate how well they think they will perform on future tasks, while females generally underestimate their abilities (Eccles et al., 1998). Likewise, a similar phenomenon has been noted among African American students. Despite generally low levels of achievement, African American students have been found to report remarkably high expectations for success, thus leading theorists to conclude that like males, African American students may tend to inflate their ratings of their academic abilities (Graham, 1994).

Although limited, some work has also been done to examine how students' reports of their self-efficacy vary by age. For example, Zusho and Pintrich (2003) have proposed that the development of self-efficacy could exhibit contrasting patterns. On the one hand, one could expect task specific judgments of efficacy to increase over time as students gain more skill and expertise at a specific task (e.g., Shell, Murphy, and Bruning, 1989). In contrast, as academic tasks get increasingly difficult, one could also expect a drop in efficacy ratings. The important point is that the development of specific self-efficacy judgments should be tied to actual experience on the task, not necessarily to general developmental trends or age-related changes in contrast to research on more global competence perceptions, which shows a very reliable and steady decline over time (Eccles et al., 1998).

Task Value

In an effort to explain why students want to succeed on a task, three components of task value have been proposed as influencing the achievement behavior within a particular content domain; these include attainment value, intrinsic value, and utility value (Eccles, 1983; Eccles & Wigfield, 1995). Attainment value refers to the importance or salience that students place on the task. Intrinsic value (i.e., personal interest) relates to general enjoyment of the task or subject matter, which remains more stable over time. Finally, utility value concerns students' perceptions of the usefulness of the task, in terms of their daily life or for future career-related or life goals. As previously mentioned, we believe that interest, which closely parallels Eccles' (1983) conceptualization of intrinsic value, is an important motivational outcome in its own right, and will therefore be discussed in greater detail in the next section.

Task Value as Mediator

The relation between instructional practices and achievement may be mediated through students' task value, such that students enrolled in science classrooms that emphasize the utility and importance of science activities will increasingly perceive the content and activities to be useful and will subsequently become more involved, use more effective learning strategies and perform better than students in traditional science classrooms. In line with certain science reform initiatives, teachers may implement inquiry-based instruction, which strives to enhance the perceived utility value for all participating students. For example, these science reform efforts attempt to increase task value by incorporating opportunities for students to engage in authentic scientific activities, by relating science content to students' everyday experiences, and by making connections to community-related issues (Marx et al., 1997). In this manner, students gain access to the science content by investigating questions and issues that they perceive to be useful and valuable to their lives outside of school.

Students' task value can influence achievement-related outcomes within the domain of science through the extent to which they choose to engage during science instruction. For example, those students who hold high utility and attainment value beliefs for the domain of science may opt to continue their coursework in the sciences, and increase their level and quality of involvement on specific tasks. In contrast, those students who have conceptions of science as unrelated to the real world, for example, may not try to master the content to the same degree. Although there is little evidence that increased task value leads directly to higher achievement, the two are positively correlated, suggesting that it is still an important construct that teachers should consider and encourage among their students (Pintrich & Schunk, 2002).

Task Value as Moderator

Task value can also serve as a possible moderator of the relation between instruction and achievement. Specifically, students who have had prior experience with such inquiry-based instruction as described above may enter the classroom with higher levels of task value compared with students who have been in more traditional science classrooms. Such students may be more receptive to instruction that highlights the utility and importance of scientific tasks. Conversely, students who may not see how science is useful or important may be especially vulnerable to declines in interest, engagement, and ultimately, achievement.

Individual Differences in Task Value

Similar to self-efficacy, gender differences have also been noted in value components of motivation. For example, Eccles, Wigfield, and their colleagues have uncovered several gender-related differences in adolescents' valuing of certain subjects (Eccles et al., 1993; Wigfield & Eccles, 1992). Specifically, they found that girls typically valued instrumental music and English more than boys, while boys valued sports more than girls. Surprisingly, male and female adolescents did not differ in the relative value they attached to mathematics until they reached high school, when boys reported valuing math more than girls. Given these domains differences, gender can moderate the general negative trajectory in the development of value or interest, but the effect will vary by domain with males more "at risk" in writing or English, while females more at risk for mathematics and sports over time.

From a developmental perspective, there is evidence that children's reports of their value for academic domains decline across the school years. It appears that elementary students report valuing schoolwork more than middle school and high school students in general (Eccles et al., 1998). Despite this overall general decline, however, the developmental progression is believed to be analogous to that of self-efficacy and competence beliefs. That is, from a task and individual differences perspective, there is reason to believe that this general trend may vary depending on the task and situation. For example, there are clearly tasks and activities that students grow to value over time, especially when they begin to have some choices about how to spend their time (Pintrich & Zusho, 2001). Thus, while there may be an overall general decline, there can be activity- or task-specific increases in task value over the course of development.

Interest

As mentioned earlier, students' interest refers to an attraction, enjoyment of, or general liking for a particular domain or academic subject (Pintrich & Schunk, 2002). Researchers often distinguish between personal and situational interest. Personal interest can be conceptualized as a personality trait or a relatively stable, enduring disposition of the person that is normally directed toward a specific activity or task, such as sports, music, or reading (Pintrich & Schunk, 2002). While personal interest is more stable and internal to the learner, another conceptualization of interest involves characteristics of the context that make a particular task or activity interesting (interestingness), resulting in situational interest, or the psychological state of being interested in a specific activity (Pintrich & Schunk, 2002). The study of interestingness has generally focused on text, and features of text passages that might be found interesting to groups of people (Hidi &

Anderson, 1992; Krapp, Hidi, & Renninger, 1992); however, it could also be applied to other domains, such as science curriculum units. In this sense, the interestingness of a particular task or content should result in situational interest that is not unique to one individual, but can be influential across many individuals. Clearly this has implications for teachers who, by increasing the interestingness of a task or lesson, can foster situational interest in their students.

Interest as Mediator

Generally, interest is assumed to be positively related to learning and, therefore, achievement because of the heightened concentration, use of learning strategies, and challenge-setting that often results from interest (Hidi, Renninger, & Krapp, 1992; Krapp & Fink, 1992; Renninger & Hidi, 2000). Therefore, situational interest can be studied as a potential mediator of achievement. For example, Harackiewicz, Barron, Carter, Lehto, and Elliot (1997) investigated the relation between college psychology students' motivation, interest, and achievement, and found a positive relation between interest and reports of higher levels of self-efficacy, which were consequently related to higher grades in the class. Similarly, Laukenmann et al. (2003) found that when physics instructors organized instruction into an initial acquisition phase and a second practice phase, during which instruction was relaxed and focused on students experiencing physics competency in small successes, situational interest was significantly related to performance on physics assessments.

Also within the domain of science, Black and Deci (2000) demonstrated how, in a college-level organic chemistry course, students' perceptions of how much their instructor supported their autonomy positively predicted students' level of interest and enjoyment in the course. Students in these classes were encouraged to be active learners by attending formal lectures, as well as intensive study groups led by advanced students, and were provided mentoring and social support (see Black & Deci, 2000, for review). This student-centered approach to teaching organic chemistry demonstrates how teachers' instructional methods can influence students' situational interest in science classes, which then impacts their level of achievement.

Interest as Moderator

Personal interest, as an internal characteristic of the student, may not be as influenced by instruction as situational interest; however, it may serve as a moderator of the relation between good instruction and achievement such that students with higher personal interest may perform better in classes than students with lower personal interest in the material. There is a noteworthy relation between interest and knowledge, which may influence how students process and learn information. For example, students may have an easier time reading and processing a text passage that is interesting compared to a non-interesting passage, because they are more likely to remember details of the interesting passage (Renninger, 1992). However, the more students become "experts" in a particular domain, the role of interest in learning would be expected to change, such that the student should be less likely to be distracted by "seductive details" and be able to identify essential points.

It is clear that knowledge and interest do not necessarily go hand-in-hand (Renninger & Hidi, 2000). For example, Hidi and Anderson (1992) reviewed a study in which students reading topics that were either unfamiliar or very familiar to them reported low levels of interest, suggesting that an optimal level of interest may result from moderate levels of prior knowledge on a topic. Interestingly, however, students who read about high-interest low-knowledge topics (Space Travel) performed worse on a writing task than students who read about low-interest high-knowledge topics (Living in a City). This suggests that even with low levels of interest, a students' broad knowledge base could buffer the detrimental effects of a boring task. Therefore, although it may be beneficial from a motivational standpoint to engage children in interesting activities, it is imperative to keep in mind that they must first be armed with sufficient knowledge to carry out the task effectively. Without proper instruction and an adequate knowledge base from which to complete academic tasks, motivational factors such as interestingness and "seductive details" may actually be detrimental to students' learning.

Finally, Schiefele, Krapp, and Winteler (1992) conducted a meta-analysis of research investigating interest as a predictor of achievement. They reviewed 121 independent random samples from 18 different countries, grade levels ranging from 5th- to 12th-grade and covering nine different subject matters. Across the entire sample of studies, interest accounted for about 10% of the observed achievement variance. Therefore, although many studies have found evidence suggesting a positive relation between interest and achievement, it is important to consider other factors such as prior achievement that explain some of the other 90% of achievement variance not accounted for by interest.

Individual Differences in Interest

Surprisingly little research has been conducted on developmental and gender differences in interest. According to Renninger (1992), children as young as three years old exhibit relatively stable personal interests, operationalized as playing with particular toys. Young children's interests tend to influence more activities and tasks than for older children, possibly due to the previously discussed relation between interest and prior knowledge. Older children and adults have more experiences with a wider array of tasks and may already have ideas of what is interesting to them and what is not. The decline in interest has also been attributed to the fact that older children, as a function of general development, begin to explore new and different interests, which distract them from interests in school-related activities (Renninger & Hidi, 2000). Interestingly, Schiefele et al.'s (1992) meta-analysis revealed that younger students' interest-achievement correlations were comparable to those of older students.

Explorations of gender differences in interest development have yielded some interesting results. Harackiewicz et al. (1997) found that among college students in an introductory psychology class, females reported enjoying the class more than males. Among elementary school students, Renninger (1992) found a gender-by-interest interaction on performance of math problems, such that boys made more mistakes on problems rated as uninteresting, whereas girls made more mistakes on interesting problems. She explains this result by suggesting that interest may facilitate boys' learning by keeping them motivated and engaged, but that interest may serve as a distraction for girls, interfering with their learning and problem solving.

Similarly, Schiefele et al. (1992) found in their meta-analysis that female students' academic performance was less related to their reports of interest than was male students' performance. Most research on gender differences in interest has focused on the domain of the natural sciences. Consistently, males were more interested (and perform better) in natural sciences while females report higher interest and earn higher grades in literature and English. These differences also tend to increase as students get older. Schiefele et al. (1992) discuss possible explanations for such differences in interest and performance by domains, such as sex differences in basic abilities that would influence learning in these particular domains; however, no conclusive results have been obtained.

There has also been a relative dearth of empirical research on ethnic differences in interest development, and there has yet been little theoretical justification for such an examination; however, this is not to say that research on other individual differences are unjustified. Future research needs to investigate the relation of interest and achievement in different academic domains, as well as examine possible gender and ethnic differences.

Achievement Goals

Another important component of student motivation concerns their general achievement goals, or their goals for academic learning and in classroom contexts. The general distinction between mastery and performance goals contrasts students who are mastery-oriented and focused on learning and understanding (similar in some ways to intrinsic motivation) and those students who are performance-oriented and focused on doing better than others in terms of grades or other outcomes that invite interpersonal comparisons (Pintrich, 2000a, b).

There is a need to examine the role of these goals with the context of various classroom environments. Many mathematics and science classrooms, especially those at the secondary and post-secondary levels, use competitive grading systems and it may be adaptive in these contexts for students to adopt performance goals. As schools and teachers make changes to improve instruction, these grading systems may change, and the goals may function differently.

Achievement Goals as Mediators

In investigating the link between teachers' instructional practices and students' motivation, much of the research has focused on the type of environment or classroom context teachers establish for their students. The extent to which students perceive that the class structure makes a specific goal salient may influence their own goal orientation toward the course material (Ames, 1992; Ames & Archer, 1988). Research has suggested that by manipulating characteristics of the classroom environment (e.g., tasks, evaluation and assessment procedures, authority), teachers can make it more likely that their students will perceive either a mastery or a performance goal focus (Ames, 1992; Pintrich & Schunk, 2002).

The second half of the mediational model involves the relation between the goals students adopt and achievement. When examining direct relations, researchers often find that mastery goals are unrelated to students' performance (cf. Church, Elliot, & Gable, 2001); however, there are indirect relations, in which mastery goals are associated with students' use of deeper learning strategies, which are then, in turn, related to higher achievement (Pintrich, 2000a). With respect to performance goals, existing research on the relation between this goal and achievement has been somewhat mixed with some researchers finding that performance goals are positively related to classroom performance (Pintrich, 2000a; Skaalvik, 1997; Wolters, Yu, & Pintrich, 1996), while others have found no significant relation (Zusho et al., 2003).

Achievement Goals as Moderators

Classroom goal structures may influence the types of personal goals students adopt; however, these structures may also interact with students' personal goals to influence achievement. One hypothesis about how students' personal goals may moderate the relation between teachers' classroom goal structures and student achievement, involves the idea of student-environment match. Under this hypothesis, performance-oriented students who are in a classroom performance context, and mastery-oriented students who are in a classroom mastery context would be expected to exhibit adaptive academic outcomes, presumably due to the congruence between their personal goals and the perceived goal structure in the classroom (Linnenbrink & Pintrich, 2001).

Recent research has begun to suggest that students are not necessarily limited to adopting either mastery or performance goals, but can adopt multiple goals (Pintrich, 2000a). Traditionally, personal mastery goals have been seen as adaptive and personal performance goals have been seen as maladaptive; however, given recent research that indicates the relation between performance goals and higher performance, this multiple goals perspective includes the idea that students may be most advantaged if they endorse high levels of both goals (Pintrich, 2000a; Barron & Harackiewicz, 2001). In line with this perspective and the student-environment match hypothesis, it has been suggested that students who endorse high levels of both mastery and performance goals may have the best academic prospects because they can selectively choose the most appropriate goal to pursue at a given time, based on the perceived demands of the classroom (Barron & Harackiewicz, 2001).

Another hypothesis of how personal goals can moderate the effect of classroom goal structure on achievement involves the notion of a "buffering" effect. As mentioned earlier, some science classrooms, especially at the secondary and post-secondary levels, employ the use of grading curves, which may serve to increase the perceived level of competition among students, perhaps making more salient to students a classroom performance goal structure. If a mastery-oriented student is placed in a performance-oriented classroom, the student's personal goals might interact with the instructional context by "buffering" the student from any negative effects of a performance context.

Individual Differences in Achievement Goals

Limited work has been done investigating the extent to which individual differences between students influence the adoption, and influence, of achievement goals. Developmentally, younger students might be more likely to adopt mastery goals because they hold incremental theories of intelligence, believing that intelligence can change over time with effort; conversely, as students get older, it is suggested that they develop more entity theories of intelligence, believing their intelligence and ability level will remain stable over time regardless of effort (Dweck & Elliott, 1983). While this belief may not necessarily be conducive to a performance goal adoption, students are less likely to believe that deeper understanding of the material will improve their ability.

The empirical support that gender influences achievement goal adoption is mixed. It has been suggested that girls underestimate their academic ability more than males, having lower expectations for success and a greater tendency to attribute failure to a lack of ability and success to luck or other uncontrollable factors (Eccles et al., 1998; Eisenberg et al., 1996; Pintrich & Schunk, 2002). This might imply that girls would be more likely than boys to adopt performance goals and less likely to adopt mastery goals; however, this is not necessarily the case. Gender stereotypes of boys being more aggressive and competitive than girls would suggest that boys are more likely to be performance-oriented than girls. Also, stereotypes of girls being more nurturing and caring than boys might translate into girls not wanting to hurt someone's feelings by beating them, thus being less likely to adopt a performance goal than boys (Eccles et al., 1998; Eisenberg et al., 1996).

The research examining cultural variation in goal adoption has been limited, although Maehr and Nicholls (1980) have proffered evidence suggesting that the goals driving achievement-related behavior might differ based on how cultures view success and failure. There has also been some speculation related to possible differences between Asian- and Anglo-American students' adoption of specific learning goals (Zusho & Pintrich, 2003). For example, citing home and schooling practices focused on the exhortation of effort and perseverance, some researchers have argued that Asians may be more mastery-oriented than Westerners (Holloway, 1988; Whang & Hancock, 1994). The empirical support for such a claim, however, has been scant. Whang and Hancock (1994), for example, found no significant differences between Asians and non-Asians in their mean level ratings of both mastery and performance goals, although they did find mastery and performance goals to be significant predictors of mathematics performance. Lee, Tinsley, and Bobko (2003), on the other hand, observed that American students place greater emphasis on mastery goals and that Asian students endorse higher levels of performance goals.

Conclusions and Future Directions

Clearly, motivation can play a significant role in student learning in science classrooms. While it is a complex phenomenon with numerous variables influencing student learning, in this chapter, we focused on four motivational beliefs, namely self-efficacy, task value, interest, and achievement goals. There are two general ways that these beliefs can influence achievement: as mediators between instructional activities and achievement, and as moderators of instructional effects (Linnenbrink & Pintrich, 2002; Pintrich, 1999; Pintrich et al., 1993). Under the mediational pathway, students' beliefs are influenced by various instructional activities, and these beliefs in turn lead to increased student achievement. In contrast, under the moderator pathway, the beliefs or strategies interact with instruction to influence student achievement.

Future directions in science education research should focus on both the mediational and moderator models, specifically on how teachers can utilize knowledge of these pathways and relations to understand how their instructional practices may affect student achievement. At the University of Michigan, we are beginning to undertake a large-scale, multi-year project, funded by the National Science Foundation, called the Math and Science Partnership – Motivation Assessment Program (MSP-MAP). Our goals for this project include the following: (1) to develop and make available reliable, valid, and practical tools to assess student motivational beliefs for mathematics and science, as well as learning strategies and epistemological beliefs, that can be used by mathematics and science classroom teachers to evaluate the effectiveness of their interventions; (2) to increase teachers' knowledge about the role of these beliefs and strategies as either mediators or moderators of instruction and how they are related to student achievement in mathematics and science, in a manner that informs the design and evaluation of interventions; and (3) to assist teachers by providing information about how student beliefs and strategies, and their linkages to student achievement, generalize or may differ as a function of gender, age, ethnicity, and socioeconomic status. We hope that by further investigating the impact of student motivation on achievement, math and science teachers may adopt and incorporate various instructional practices in their classrooms, which could lead to optimal levels of motivation among students, and subsequent higher achievement.

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Figure 1a
How motivational beliefs mediate the relation between instruction and achievement

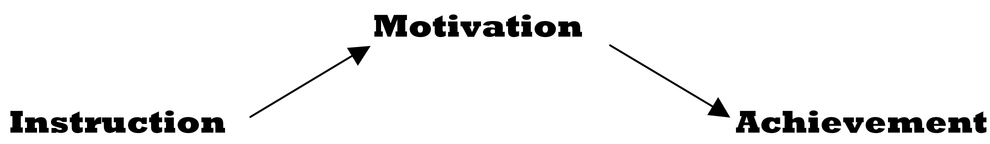

Figure 1b
How motivational beliefs moderate the relation between instruction and achievement