Overview: Self-Efficacy in STEM

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"…Women aptly competent in mathematics often fail to pursue mathematics-related careers because they have low self-efficacy perceptions about their competence" – Zeldin and Pajares (2000)

A landmark report by the American Association of University Women (AAUW, 1991), *Shortchanging Girls, Shortchanging America*, revealed that girls' confidence in their academic abilities drops dramatically from elementary to high school. The decline is particularly significant in girls' and young women's belief in their math and science abilities. At every age, from elementary to high school, boys are more confident in their math abilities than are girls. Boys and girls interpret their grades and performance in STEM differently. For example, in a science class, a girl might view a B on an exam as a poor grade, indicative of her lack of science ability. A boy receiving a C on this same exam might view the grade as passing and therefore indicative of his strong science ability (Seymour, 1995). Research also shows that young women and girls who receive high grades in STEM are generally modest while young men and boys are generally self-congratulatory (Schunk & Pajares, 2002). By high school, one in four boys thinks he is good at math but only one in seven girls thinks she is (AAUW, 1991). The "confidence gap" (Sadker & Sadker, 1994) refers to gender differences in belief in math and science abilities. This gap is partly responsible for the shortage of women in science, technology, engineering, and mathematics (STEM) classes and careers (e.g., Eccles, 1994).

Belief in one's ability to perform a specific task is referred to as self-efficacy. Self-efficacy is defined as a judgment about one's ability to organize and execute the courses of action necessary to attain a specific goal—self-efficacy judgments are related to specific tasks in a given domain (Bandura, 1997; Pajares, 2005; Zimmerman, 2000). Self-efficacy is goal directed—self-efficacy assessments direct respondents to rate their level of confidence for attaining a specific goal. Math self-efficacy, for example, could be assessed by the following questions, "How confident are you that you can pass mathematics at the end of this term?" and "How confident are you that you can get a grade better than a B in mathematics?" (Bong & Skaalvik, 2003).

Self-efficacy influences the choices individuals make in term of goal choice, the effort expended to reach those goals, and persistence when difficulties arise (Bandura, 1997; Pajares, 2005). Self-efficacy is a significant predictor of both the level of motivation for a task and ultimately task performance (Bandura & Locke, 2003); on average, individuals with high STEM self-efficacy perform better and persist longer in STEM disciplines relative to those lower in STEM self-efficacy. Moreover,

- Self-efficacy positively predicts performance beyond prior performance and ability (Bandura, 1997; Bandura & Locke, 2003).

- Whereas the most influential source of STEM self-efficacy for boys and men is mastery experience, the most influential sources of STEM self-efficacy for girls and women are vicarious experience and social persuasion (e.g., Zeldin & Pajares, 2000).
- Gender differences, favoring men, have been observed in STEM self-efficacy, and also in the probability of success in STEM-related fields (e.g., AAUW, 1991; Schunk & Pajares, 2002).
- The "confidence gap" exists *despite* comparable prior accomplishments for men and women, such as STEM course grades (e.g., Watt, 2006; see also Pajares, 2005 for a review).
- The "confidence gap" is partly responsible for the "gender gap" in engineering and other STEM disciplines, including computer science, physics, and astronomy. The "gender gap"—a sizeable difference in the number of women and men pursuing study or careers in STEM fields—develops with advanced high school math and science course enrollment and grows at each successive stage: Women earn only 29.1 percent of mathematics and computer science bachelor's degrees and 24.7 percent of doctorate degrees in mathematics and computer science, and hold 27 percent of professional mathematics and computer science positions (AAUW, 2008).
- Practitioners can bolster students' STEM self-efficacy through various interventions, but to do so without consideration of students' ability is unwise (Forsyth, Lawrence, Burnette, & Baumeister, 2007).

Some recent research (e.g., Britner & Pajares, 2006; Chen & Zimmerman, 2007; Kay & Knaack, 2008; Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006) suggests that the "confidence gap" may be closing, disputing gender differences in STEM self-efficacy. For instance, some middle school girls have higher science self-efficacy than do boys, and other studies have found no gender differences in math or computer self-efficacy. What is not disputed, however, is that self-efficacy influences interests, goals, performance, and persistence (Eccles, 1994; Lent, Brown, & Hackett, 1994). Moreover, high STEM self-efficacy is a stronger predictor of vocational choice for girls than for boys (Larose, Ratelle, Guay, Senécal, & Harvey, 2006).

The following literature overview presents self-efficacy as a key predictor of STEM performance and perseverance. First, a more detailed definition of self-efficacy, its determinants, and its importance within STEM disciplines are discussed. Second, interventions and programs to increase STEM self-efficacy are reviewed and effective aspects of the interventions are highlighted. Third, implications and recommendations to practitioners are proposed. Lastly, the state of current research, as well as areas for future STEM self-efficacy research, is summarized.

Self-Efficacy

Self-efficacy, self-concept, and self-esteem are similar constructs that differ in meaningful ways (Bong & Skaalvik, 2003; Gist & Mitchell, 1992; Pajares, 2005; Zimmerman, 2000). Self-efficacy judgments reflect task-specific performance expectations; for example, "I believe that I can get a B or better on my math test." Self-efficacy judgments are not inherently evaluative and they are made without consideration of others' capabilities (Bong & Skaalvik, 2003; Gist & Mitchell, 1992). Rather, self-efficacy beliefs are based largely on mastery experience, an individual's task-specific experiences, and interpretation of those experiences.

Alternatively, self-concept beliefs are more general self-perceptions related to a domain that can include an evaluative or affective component; for example, "I am good at math" or "I enjoy math" (Bong & Skaalvik, 2003). Like self-efficacy, self-concept is a motivational construct in that it influences the types of goals pursued, and effort and persistence in reaching those goals. Unlike self-efficacy, self-concept is not related

to a specific task. Self-concept and self-efficacy are often positively related to one another, and develop similarly through self-judgments about achievement. However, these constructs can be distinct: for example, a person could have a high science self-concept but have low self-efficacy for passing any particular science exam for a variety of reasons (e.g., did not study, does not like the particular material). This example also illustrates how self-efficacy for a task influences self-concept—if self-efficacy is consistently low for tasks within a domain, self-concept in that domain will be negatively affected.

Self-efficacy and self-concept are also closely related to, and partly based on, self-esteem. Self-esteem refers to an affective evaluation of the self, such as feelings of self-worth and self-like (Gist & Mitchell, 1992). Whereas self-concept is generally considered specific to a domain (e.g., math or verbal ability) and self-efficacy is considered specific to a task or goal, self-esteem represents global, evaluative feelings (Gist & Mitchell, 1992, p. 184).

Because it is more directly related to performance on a specific task, self-efficacy is generally a better predictor of task-specific performance than self-concept (Bong & Skaalvik, 2003; Britner & Pajares, 2006; Zimmerman, 2000). Self-efficacy is thought to influence task performance through goal setting and self-regulation during performance (Bandura, 1991; Pintrich, 2003; Zimmerman, 2000). Self-regulation includes self-monitoring or assessing one's performance during task execution as well as monitoring the outcomes of performance. Research suggests, for example, that high self-efficacy is related to greater cognitive engagement in a task (Pintrich, 2003).

Self-efficacy also affects the goals individuals set. Higher self-efficacy is related to the adoption of more challenging goals and greater commitment to those goals. Moreover, self-efficacy influences whether discrepancies between performance and goals are motivating or discouraging. For example, a student's goal grade for her upcoming math test is an A, and she earns a B. If she has high self-efficacy she will attribute her shortcoming to insufficient effort, "If I had studied more, I could have earned an A. Next time I will work harder." However, if she has low math self-efficacy she will attribute her shortcoming to lack of ability, "I just don't get this material; I am not capable of getting an A in this course" (Zimmerman, 2000). Self-efficacy is particularly important as individuals work toward long-term goals (i.e., end goals), such as passing calculus or earning an engineering degree. Progress toward the end goal is marked by many smaller, proximal goals (Bandura, 1991). These proximal goals could include getting a B on a calculus test or completing degree requirements, such as physics and mechanics. Proximal goals provide opportunities for task-specific mastery experience that strengthen self-efficacy.

The Development of STEM Self-Efficacy

Self-efficacy beliefs are developed through the interpretation of task outcomes and the circumstances surrounding task experiences. Self-efficacy beliefs are based on four primary sources of information: mastery experience, vicarious experience, social persuasion, and physiological reaction (Bandura, 1997; Gist & Mitchell, 1992; Pajares, 2005).

1. *Mastery experience* refers to previous task experience and performance. Mastery experiences are opportunities to learn and practice the rules and strategies necessary to perform a task effectively. Moreover, mastery experiences provide evidence of whether an individual has the capability to succeed. If a student earned an A on his last test, then he is likely to feel confident that he can earn a high grade on his next math test; however, if he earned a D on his last test, then he is more likely to doubt his ability to do well on the next math test. Typically, successful outcomes boost self-efficacy whereas failures lower it.

2. *Vicarious experience* refers to learning through observing others perform tasks. For example, while observing a more advanced student, a novice thinks, "If she can design and construct a working robot, so can I." Role models are especially influential when they are perceived as similar to the observer, suggesting that interaction with female faculty members and advanced students in STEM would positively affect the self-efficacy of female STEM students. Indeed, research suggests that vicarious experience is a particularly powerful determinant of girls' and young women's STEM self-efficacy (Seymour, 1995; Zeldin & Pajares, 2000).

3. *Social persuasion* refers to others' judgments, feedback, and support. Positive feedback and encouragement, especially from influential others (e.g., parents, teachers), enhances self-efficacy. Negative feedback erodes self-efficacy. Although almost any negative remarks will decrease self-efficacy, not just any positive comments will increase it. Positive feedback and praise is most effective when it is aligned with past performance and actual ability. The receiver of the feedback must perceive the feedback to be genuine. For example, a B student who earns a C on an exam should be encouraged to aim for a B+, rather than an A+, on the next exam; whereas, an A student who earns a C on an exam should be encouraged to work toward an A on the next exam. Furthermore, social persuasion is particularly powerful when it accompanies a mastery experience (Bandura, 1997)—that is, feedback about task-related strengths and weaknesses is more informative when it is tied to a specific learning experience or previous performance (Betz & Schifano, 2000; Pintrich, 2003). For example, research has shown that when women received positive feedback related to specific events in training, their self-efficacy for the trained tasks was increased (Betz & Schifano, 2000).

4. *Physiological reaction* also affects self-efficacy. An individual interprets his or her emotional and physical states to determine his or her self-efficacy beliefs. If "butterflies," nervousness, and a fear of failure occur during task preparation, an individual is likely to doubt his or her ability to succeed, and the increased anxiety is likely to have a detrimental effect on performance.

The Importance of STEM Self-Efficacy

STEM self-efficacy predicts academic performance beyond one's ability or previous achievement because confident individuals are motivated to succeed. Students with high science self-efficacy set more challenging goals and work harder to accomplish those goals than students with low science self-efficacy. Additionally, high self-efficacy is associated with greater self-regulation, including more efficient use of problem-solving strategies and management of working time (Zimmerman, 2000). In addition to expending greater effort, efficacious individuals persist longer to complete a task, particularly in the face of obstacles and adversity (Pajares, 2005; Zimmerman, 2000). Therefore, on average STEM self-efficacy is positively related to STEM task performance. For example, science self-efficacy is related to students' grades in science class (Britner & Pajares, 2006).

The relationship between self-efficacy and performance is reciprocal and on-going, whereby successful task performance boosts self-efficacy leading to the adoption of more difficult goals. The adoption of more difficult goals requires greater effort, which will positively affect performance. Successful performance with the new, more difficult, goal will, in turn, lead to even greater self-efficacy and thus the cycle continues (Bandura, 1997). Because of the reciprocal self-efficacy – performance relationship, it is important that beliefs about one's capabilities are accurate (Bandura, 1997; Pintrich, 2003). Being over- or under-confident can undermine performance. Assume two students have comparable math ability, but very different perceptions of their math abilities; one has relatively high math self-efficacy and the other has relatively low math self-efficacy. The student with high self-efficacy sets a high goal grade for the upcoming exam. To the extent she overestimates her ability to solve algebra problems, she is likely to put forth less effort studying than is necessary and will likely not earn her goal grade. Moreover, being over-confident, she may disregard the negative exam results in order to preserve her unrealistically high self-efficacy (Pintrich, 2003; Vancouver & Kendall, 2006). The student with low self-efficacy sets a low goal grade (e.g., C). Discouraged by her perceived lack of skill in algebra, she studies only enough to get the grade she believes she is capable of earning and may get a grade far below what she could have earned. Furthermore, her mediocre exam grade may affect her subsequent math self-efficacy and make her less likely to pursue more advanced math courses, despite having the capability to solve algebra problems and succeed in more advanced math courses (Eccles, 1994; Pajares, 2005).

Self-efficacy is also positively related to interest and engagement (Schunk & Pajares, 2002), and this relation is reciprocal as well. Self-efficacy predicts initial engagement and task performance; in turn, success leads to greater intrinsic interest and a greater likelihood of engaging in that task in the future, often at a more challenging level. In fact, individuals with high self-efficacy enroll in more challenging courses than do individuals with low self-efficacy (Watt, 2006) because they perceive demanding tasks as challenges rather than threats. Highlighting the importance of perceptions of abilities rather than actual abilities for influencing motivation, research shows that interest is more highly related to self-efficacy than actual ability (Bandura, 1991). This finding helps explain why many girls and young women lose interest in STEM even though they do not lack STEM abilities. What they lack is the belief that they are capable of attaining STEM goals—such as certain grades, majors, or professions—which leads to decreased interest in pursing STEM (Eccles, 1994; Seymour, 1995). As one female engineering major put it, "…confidence that you can do this… that's what you need" to persevere in the discipline (Seymour, 1995, p. 450).

Interventions and Programs to Increase STEM Self-Efficacy

Numerous interventions and programs to increase STEM achievement have been investigated in research laboratories and implemented in classrooms and communities. Most of these interventions were not designed specifically to increase STEM self-efficacy, but because increased achievement leads to

increased self-efficacy, we can examine the effect of these interventions on STEM related self-efficacy. The interventions are discussed in relation to the developmental antecedents of self-efficacy.

Mastery Experience Interventions. Many STEM instructors include mastery experiences, such as laboratory work, experiments, design projects, and other applied activities, as part of the course curriculum. For example, to provide mastery experiences, an elementary school computer class included a hands-on exercise on Web page creation. Similarly, a high school science course included hands-on exercises for teaching water quality including field trips to area lakes to gather water samples, which were subsequently tested for chemical imbalance by the students (AAUW, 2004).

A number of after-school programs, workshops, and summer camps have also been designed to provide girls and boys of all ages with opportunities to gain STEM knowledge and skills through hands-on experience (AAUW, 2004). After-school programs and clubs exist for nearly all STEM disciplines and have included a variety of activities, such as building rockets and robots, programming computers, and dissecting owl pellets. Various day and residential summer camps, especially for high school students, have been implemented to provide real-world involvement in STEM fields. For instance, one program invited high school girls to work in a college bioinformatics lab.

Research has shown that interventions involving mastery experiences do indeed increase STEM self-efficacy (e.g., Betz & Schifano, 2000; Dunlap, 2005; Luzzo, Hasper, Albert, Bibby, & Martinelli, 1999). The following two studies suggest that the key to the effectiveness of these interventions is the inclusion of proximal goal setting and self-regulation:

> Dunlap (2005) assessed the effect of mastery experience on college students' technology self-efficacy. Students were assigned a real-world problem and required to structure their problem resolution by setting proximal goals and creating action plans as they worked to solve the problem. This project lasted 16 weeks, and students were continuously encouraged to incorporate new knowledge and skills and to reflect on their use of resources and strategies as well as their performance (i.e., self-regulation). At the end of this 16-week program, students reported significantly higher technology self-efficacy.

> Luzzo and colleagues (1999) increased students' self-efficacy through a mastery experience intervention involving a proximal goal manipulation. They structured a number series completion task, introduced as a measure of math ability, so that success (defined as successful completing six trials) was very likely. Half of the student participants were told that the minimum passing score was successful completion of six trials (proximal goal manipulation); the other half were told nothing. The "proximal goal" participants not only reported greater STEM self-efficacy compared to the control group immediately after the intervention, but they also reported greater STEM self-efficacy four weeks after the intervention. Luzzo et al.'s findings suggest that even minor, somewhat contrived interventions can have a significant impact on self-efficacy.

Social Persuasion Interventions. Positive feedback and encouragement builds self-efficacy. One important source of social persuasion, or support, is students' parents. Parents' encouragement and expectations have been shown to be a more important predictor of a child's self-efficacy than a child's own involvement in the activity (Vekiri & Cronaki, 2008). More specifically, mothers' beliefs regarding their children's ability to succeed in math careers was significantly related to the children's later career choices (Bleeker & Jacobs,

2004). This research suggests that teachers' and practitioners' belief in students' STEM abilities can influence students' interests, as well as educational and professional pursuits.

Research (e.g., Betz & Schifano, 2000; Luzzo et al., 1999; Vogt, 2008) has also found that positive feedback from others (i.e., social persuasion) increases the impact of mastery experience on self-efficacy. Betz and Schifano conducted a workshop for young women focused on engineering knowledge and skills (e.g., machine design, tool use, and construction). While participants completed building and repairing activities, instructors provided constructive feedback and encouragement. Positive verbal persuasion is particularly important for girls and young women (Zeldin & Pajares, 2000) and yet frequently not provided in STEM fields (Seymour, 1995).

Vicarious Experience Interventions. Interventions to increase STEM self-efficacy, both inside and outside the classroom frequently include opportunities to learn from observing others. Vicarious STEM-related experiences are especially influential for girls and young women under certain conditions (Zeldin & Pajares, 2000). Research studies of vicarious experience interventions have shown that they are more effective when employed in conjunction with other interventions (e.g., Luzzo et al., 1999) and when the role model is similar to the observer (Bandura, 1997).

A variety of vicarious experiences have been incorporated into course curricula, including inviting STEM professionals to give field- or career-specific lectures or to work on projects with students. Shadowing STEM professionals at work is another method for providing vicarious experiences. For example, a two-fold project to improve awareness of science careers and gender equity in science included girls' production of radio segments and video programs of interviews with professional STEM women and the distribution of the CDs of these role-model interviews to K-12 school girls (AAUW, 2004).

Various workshops and camps have also been implemented to expose girls and young women, especially those who lack professional female role models, to women with STEM careers (AAUW, 2004; Weisgram & Bigler, 2006). Many of these programs have the goal of providing young women with role models in STEM and involve female STEM professionals, not only as instructors, but also as on-going mentors to the participants. In addition to introducing them to science and math concepts, the professionals provide continual STEM-related career advice and professional network access.

Additionally, recent research (Weisgram & Bigler, 2007) has shown that a role model's effect on young women's STEM self-efficacy was greater when the role model addressed gender inequity in STEM fields. Young women who attended a session about gender discrimination in scientific fields reported significantly higher science self-efficacy than those who did not. The gender discrimination presentation included examples of ways that gender discrimination affects female scientists today, as well as the biographies of four famous female scientists who faced gender discrimination during their careers. The researchers proposed that the gender discrimination session may have positively affected girls' self-efficacy because it led them to reinterpret past negative feedback about their own and females' performance in science to discrimination rather than lack of ability (see Crocker & Major, 1989, for further explanation of the stigma attribution theory). The researchers caution against a gender discrimination in science lecture presented in isolation; these women were also exposed to successful female scientists. Additionally, it is important to note that these women also had at least some interest in science disciplines and chose to attend this conference.

A couple of guidelines for self-efficacy interventions are warranted. First, interventions to increase STEM self-efficacy should include a realistic assessment of aptitude. The effective interventions discussed above targeted individuals who had at least some aptitude or interest in a STEM field (e.g., Betz & Schifano, 2000; Luzzo et al., 1999; Weisgram & Bigler, 2006, 2007). Without STEM aptitude or interest, it is doubtful that any intervention would increase self-efficacy. Moreover, interventions designed to increase self-efficacy without a consideration of actual ability may lead to decrements in performance and decrements in subsequent self-efficacy. As discussed above, self-efficacy should lead to the pursuit of difficult but attainable proximal goals. However, self-efficacy interventions that overstate a student's actual ability may encourage the student to engage in unproductive behaviors such as adopting an unattainable goal grade or failing to prepare adequately for an upcoming exam.

Second, interventions that boost self-esteem without consideration of actual performance have been show to be ineffective for increasing performance in academic domains (e.g., Forsyth et al., 2007; see also Pintrich, 2003). It seems that feeling better about oneself in general does not lead to behavior related to improving oneself. In summary, to increase students' performance and belief in their ability to perform a specific task, feedback must be accurate and focused on developing task-related knowledge and skills (AAUW, 2004; Pintrich, 2003).

Implications and Recommendations for Practitioners

The research on self-efficacy suggests that practitioners should pay as much attention to students' self-efficacy—their perceptions of capability—as they do to students' actual capability (Zeldin & Pajares, 2000). Below, strategies to bolster students' STEM self-efficacy are presented in terms of the primary determinants of self-efficacy:

Mastery Experience. Because individuals interpret the outcomes of their behavior and actions to form beliefs about their capability to achieve future goals, mastery experience is a significant predictor of self-efficacy (Bandura, 1997; Britner & Pajares, 2006). Accordingly, practitioners should integrate mastery experience opportunities into STEM courses:

- Incorporate hands-on, laboratory-based activities and projects that require self-regulation into the course curriculum.
- Tailor activities to students' ability-level so that they are challenging but not impossible.
- Structure activities to include proximal goals.
- Maximize the impact of the mastery experience by providing feedback and encouragement (i.e., social persuasion). Help students interpret these experiences in ways that enhance self-efficacy.

Vicarious Experience. Vicarious experience is particularly informative when individuals have limited mastery experience. With little or no first-hand experience, an individual infers his or her capability level based on the performance of others who are perceived to be similar. Opportunities to observe the successes of others have been found to be especially influential for the STEM self-efficacy of girls and women (Zeldin & Pajares, 2000). Practitioners should create vicarious learning experiences that incorporate opportunities for students to observe the practice and performance of their peers and STEM professionals in STEM courses:

- Assign group-work in which the groups are carefully composed of similar ability students. Ideally, at least one group member has slightly higher math or science skills and serves as a model to the other members of the group.
- Invite more advanced (e.g., high school, undergraduate, or graduate) STEM students and STEM professionals into classrooms to work with students (e.g., solving math problems or conducting a science experiment) or share their STEM experiences and success.
- Role models are particularly influential (i.e., positively affect students' self-efficacy) when students perceive similarities between the models and themselves. For instance, a girl's science self-efficacy is more positively affected by interacting with a young female chemist than an older male chemist.

Social Persuasion. Social persuasion is particularly instrumental in the development and maintenance of girls' and women's STEM and career self-efficacy (AAUW, 1991; Seymour & Hewitt, 1997; Zeldin & Pajares, 2000), perhaps because STEM disciplines are typically more competitive than non-STEM disciplines (e.g., Seymour, 1995). The majority of girls and young women who pursue STEM studies have been influenced and encouraged to do so by family, teachers, and other significant adults (Seymour & Hewitt, 1997). To increase STEM self-efficacy, practitioners should:

- Give feedback and support that is positive but genuine, appropriate, and realistic.
- Encourage students to persist despite difficulties and setbacks; success in STEM is the result of effort.
- Inform parents and guardians of the importance of supporting their students, especially girls and young women, in STEM studies and interests.
- Educate students and their families about the importance, value, and range of STEM fields and careers.
- Emphasize that STEM fields and careers are equally appropriate for both males and females.
- Provide students and their families with information about extra-curricular STEM activities, such as after-school clubs, camps, local lectures and exhibits, and encourage them to participate.

Physiological Reaction. Feeling calm and composed, rather than nervous and worried, when preparing for and performing a task leads to higher self-efficacy. To reduce anxiety and apprehension, practitioners should:

- Discuss the experience of math- and science-related anxiety with students and tell them that they can control their physiological reactions.
- Teach students effective anxiety-management strategies, including breathing and visualization exercises, as well as relaxation techniques.
- Encourage students to attend fully to the task at hand, which should reduce attention paid to apprehensions and fears thereby reducing task-related anxiety.

State of Current STEM Self-Efficacy Research and Areas for Further Study

Current research on STEM self-efficacy is assessing the effectiveness of various self-efficacy interventions and further examining how self-efficacy is related to other predictors of academic performance such as goal choice (e.g., Eccles' model of achievement-related choices, see Eccles, 1994). More longitudinal studies of self-efficacy are also being conducted. For example, researchers are exploring how self-efficacy changes throughout elementary, secondary, and post-secondary education, as well as the long-term effects of self-

efficacy interventions. One active line of longitudinal research is examining how an individual's self-efficacy affects his or her performance over time (e.g., Vancouver & Kendall, 2006). This research addresses questions related to how prior performance influences the development of self-efficacy, and how self-efficacy relates to subsequent performance. Interestingly, these studies have found that in some circumstances, high self-efficacy leads to less effort, which adversely affects performance. This finding reinforces the notion that self-efficacy should not be blindly boosted and highlights the need to further research on the elements of effective self-efficacy interventions.

To close the confidence gap, and ultimately the gender gap in STEM, future research on STEM self-efficacy should explore the effects of altering STEM performance attributions and perceptions of STEM disciplines. Many researchers suggest that practitioners emphasize success in STEM is the result of effort—not chance or gender—and that girls and women, in particular, are taught to attribute success to ability and effort. The effectiveness of this type of intervention has not been empirically investigated. Researchers (e.g., Pajares, 2005) also propose that practitioners challenge the long-held perception that science, technology, engineering, and mathematics are *male* domains (Pajares, 2005). To this end, practitioners are encouraged to present STEM topics as relevant and valuable educational and vocational opportunities to both men and women. More specifically, it has been proposed that girls and young women would benefit from learning about the various jobs, especially those with a people-oriented component, in engineering and other male-dominated STEM fields (e.g., Eccles, 1994). Recent research (e.g., Weisgram & Bigler, 2006) also suggests that young women will benefit from learning about gender inequity in STEM. Future research should assess the extent to which such interventions can change perceptions of STEM disciplines and the pursuit of STEM degrees and professions.

(For a practice-oriented guide on this topic or other ARP Resources, go to: http://www.AWEonline.org/ARPResources.aspx)

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