



Self-Efficacy in STEM: Information Sheet



"... 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)

Anne and Elizabeth are enrolled in the same mathematics course and have equivalent math aptitude. The course mid-term is approaching, and Anne is confident that she can pass the exam. Elizabeth, however, does not believe that she can pass the exam. Both Anne and Elizabeth receive Bs on the exam. Believing in her math ability, Anne is motivated to try harder next time. But, Elizabeth, doubting her math ability, is discouraged and interprets the B as a sign that she does not understand the material and cannot succeed in the course. At the end of the term, Anne has earned in A in the course and Elizabeth, whose performance declined, has dropped the course.

In the example above, Anne and Elizabeth have equal aptitude for math, but their beliefs regarding their math abilities differ. Anne believes she can earn passing grades in math; Elizabeth does not. Belief in one's ability to perform a specific task is referred to as self-efficacy. Self-efficacy is defined as judgments regarding 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). Math self-efficacy, for example, could be assessed by the following question, "How confident are you that you can get a grade of B or better in mathematics?" (Bong & Skaalvik, 2003).

Efficacious students are motivated to succeed; they set higher performance (e.g., grade) goals, expend more effort to reach those goals, and are more resilient when difficulties arise (Bandura, 1997). Consequently, individuals with high science, technology, engineering, and mathematics (STEM) self-efficacy typically perform better and persist longer in STEM disciplines than those with relatively lower STEM self-efficacy (Britner & Pajares, 2006; Pajares, 2005). Moreover, self-efficacy predicts academic achievement beyond one's ability or previous achievement (e.g., Bandura, 1997). For example, think of Anne and Elizabeth. Both students are capable of mastering the material in their math course, and both earned Bs on the math mid-term exam. Yet, despite comparable math ability and previous achievement, Anne and Elizabeth have different beliefs in their ability to do math: Anne believes she can do well in math, Elizabeth does not. It would be predicted that Anne and Elizabeth would thus differ in their math achievement at the end of the term. Specifically, Anne's greater self-efficacy should lead to better academic performance overall.

Much research has documented gender differences, favoring men, in STEM self-efficacy, and also in the probability of success in STEM-related fields (e.g., AAUW, 1991; Schunk & Pajares, 2002). The gender difference in perceived STEM capability has been coined the "confidence gap" (Sadker & Sadker, 1994). The "confidence gap" exists *despite* comparable prior accomplishments, such as STEM course grades (e.g., Watt, 2006; see also Pajares, 2005 for a review) and is partly responsible for the "gender gap" in engineering and other STEM disciplines, including computer science, physics, and astronomy (AAUW, 2008).

The Development of STEM Self-Efficacy and Recommendations for Practitioners

Self-efficacy beliefs are developed through the interpretation of performance outcomes. These 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 experience and performance with a given task. Mastery experiences provide evidence of whether an individual has the capability to succeed. Successful outcomes boost self-efficacy whereas failures lower it. Research shows that mastery experiences are significant predictors of self-efficacy (Bandura, 1997; Britner & Pajares, 2006). Accordingly, practitioners should integrate “mastery experience” opportunities into STEM courses:
 - Incorporate into the course curriculum hands-on, laboratory-based activities and projects that require self-regulation.
 - 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.
2. *Vicarious experience* refers to learning through observing others perform a given task. Role models are especially influential when they are perceived as similar to the observer. This suggests that interactions with female faculty members and advanced students in STEM would positively affect the self-efficacy of female STEM students and individuals with little or no first-hand task experience. Indeed, opportunities to observe the successes of others are influential for the development of STEM self-efficacy for 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.
 - Provide Role models, which 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.
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. Feedback and praise is most effective when the individual has ability, at least some confidence in his or her capabilities, and a belief that success is attainable. 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). To increase STEM self-efficacy, practitioners should:

- Give feedback and support that is positive, genuine, appropriate, and realistic—students see through false praise.
 - 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, 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 not more appropriate for males than 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.
4. *Physiological reaction* also affects self-efficacy. An individual's self-efficacy is based in part on interpretation of his or her emotional and physical states during task preparation and performance. 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.

Conclusion

It is important that in addition to developing students' knowledge and skill, STEM practitioners help develop students' self-efficacy in STEM pursuits. Greater self-efficacy—belief in one's ability to attain a specific goal—leads to greater effort, performance, and persistence. For girls and women, the lack of self-efficacy potentially leads to the avoidance of STEM-related courses and careers (Pajares, 2005). Educators can best build students' STEM self-efficacy by providing them with STEM opportunities, experiences, and role models and by encouraging them to pursue STEM interests and persist despite difficulties.

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

References

- American Association of University Women. (1991). *Shortchanging girls, shortchanging America: Executive summary*. Washington, DC: Author.
- American Association of University Women (2008). *Women and girls in STEM*. Washington, DC: Author.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W. H. Freeman and Company.
- Bong, M., & Skaalvik, E. M. (2003). Academic self-concept and self-efficacy: How different are they really? *Educational Psychological Review, 15*, 1–40.
- Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*, 485–499.
- Gist, M. E., & Mitchell, T. R. (1992). Self-efficacy: A theoretical analysis of its determinants and malleability. *Academy of Management Review, 17*, 183–211.
- Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 294–315). New York: Cambridge University Press.
- Sadker, M., & Sadker, D. M. (1994). *Failing at fairness: How America's schools cheat girls*. New York: Scribner.
- Schunk, D. H., & Pajares, F. (2002). The development of academic self-efficacy. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation: A volume in the educational psychology series* (pp. 15–31). San Diego: Academic Press.
- Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.
- Watt, H. M. G. (2006). The role of motivation in gendered educational and occupational trajectories related to math. *Educational Research and Evaluation, 12*, 305–322.
- Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*, 215–246.
- Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*, 82–91.