Girls and Young Women—Gender Equity in Science Education for K–12 Classrooms

By Dale Baker, Ph.D., Arizona State University

Table of Contents

Introduction

This paper identifies instructional strategies, curricula, and organizational structures that have been successful in promoting equity in science classrooms for girls and young women. Some recommendations are specific to young children, but all hold across grade levels and science content areas and work for underrepresented and diverse students in science.

Pre-K and Kindergarten

Young girls, in pre-K and kindergarten, engage in gender stereotyped behavior and are less likely than boys to choose science activities for free choice play. The National Science Teachers Association (2014) recommends that young children be provided with long term exploratory activities on a topic that peaks curiosity. They should also be provided with multiple and varied opportunities to engage in science, especially out of doors (e.g. exploring how animals move, playing with light and shadows) and activities should be open-ended allowing for multiple answers rather than one correct answer. Teachers should ask questions of boys and girls equally and provide opportunities to talk about science experiences insuring that boys do not dominate discussions. The intent is to develop an early interest in science that will sustain girls throughout their education and build on their natural curiosity.

Literature is a core part of the early childhood curriculum. Using non-fiction literature, in conjunction with science inquiry activities (e.g. science-based books about how plants grow and creating, tending and harvesting a school garden), is an effective way to increase young girls' understanding of science and their perception of themselves as competent science learners (Patrick, Mantzicopoulous, and Samarapungavan 2009).

Self-efficacy

Competence and confidence, or more specifically, self-efficacy as a science learner is critical for girls' and women's achievement, persistence, and choosing a science career. Self-efficacy, especially in terms of feelings of mastering a task or concept, can be increased by providing girls with science-related activities that are at the right level of difficulty for successful completion. Mastery is also enhanced by hearing positive messages about competence.

Bringing science peer role models to the classroom is another way that teachers can increase selfefficacy in science and develop a science identity (Baker 2013). Since self-efficacy predicts girls' achievement in the critical years of middle school, teachers and curriculum planners should reduce sexbased threats by providing low risk activities that are not perceived as more appropriate for males or only of interest to males (Vincent-Ruiz and Schunn 2017).

Curriculum and Pedagogy

Appropriate curriculum and pedagogy are important for promoting gender equity in classrooms (Baker 2016). Worksheets, cookbook science labs, individual work, teacher centered lectures, abstract topics, and work that is not at the appropriate difficulty level all fail to engage girls and promote interest and learning in science (Fredericks, Hofkens, Wang, Mortensen and Scott 2018). What does engage and promote learning are student centered active learning tasks, open ended real-world problems that address the concerns and interests of girls (e.g. animals), collaborative work monitored for equitable male/female participation, and group discussions. Girls also need to feel that what they are learning is useful, personally relevant, related to life in and out of school and to career interests (Fredericks, et al. 2018). Teachers who include student interests can still address curriculum objectives with some thought. For example, lessons on forces using amusement park rides is gender neutral physics and of interest to all students.

In addition to personally authentic activities, culturally responsive curricula build upon students' strengths, culture, and experiences insuring that curricula are not dominated by male experiences. The inquiry skills of obtaining, evaluating, and communicating information fit well with culturally responsive pedagogy when inquiry reflects students' funds of knowledge such as analyzing the nutrition of fast food and communicating results (Brown 2017). Responsive curricula also support problem solving and cyberlearning (Crippen and Antonenko 2017).

English language learners, whether girls or boys, struggle with the gap between everyday and scientific language making addressing the science communication standards difficult. Two strategies that have proven supportive in developing the skills of scientific discourse and argumentation among English language learners and providing opportunities to learn are using small groups of students (e.g. pairs which appeal to girls) and allowing talk in both the native language and English (Gonzalez-Howard, Maria and Katherine McNeill 2016).

Engineering in the Classroom

To address the Next Generation Science and Engineering Standards and to enhance achievement, especially among low achieving middle school African American girls, teachers should integrate designbased activities and tinkering into science (Mehalik, Doppelt, and Schunn 2008). Activities such as building an electrical alarm system to learn about electricity fulfill both science and engineering standards and help develop an engineering identity for girls (Carberry and Baker 2017). These activities are particularly important since elementary students when asked to draw an engineer, draw males (Capobianco, Diefes- Dux, Mena and Weller 2011).

The Flipped Classroom

Some curricular and pedagogical approaches are too new to recommend. Not much is known about the impact of the flipped classroom in K–12 education and what is reported is anecdotal rather than empirical. Studies are mixed with some reporting a positive impact and others no impact (Lo, and Hew 2017). Nor, is there much about whether gender differences exist. However, what research exists reinforces what we already know about promoting classroom equity. For girls, the design of online materials and topics of interest are critical components of satisfaction in an on-line learning environment (Chen, Young and Hsiao 2015). Girls prefer a structure that facilitated on-line discussions, is well connected to classroom activities, provides supportive feedback and enough time to finish assignments. Without these components, girls disengage and are discouraged. In addition, it is not clear that what happens on-line is important for learning, but rather how the teacher structures the in-class portion of instruction. Jenen, Kummer, and Gody found no difference in learning between flipped 5-E lessons and non-flipped 5-E lessons leading them to attribute learning to active classroom learning alone (2015).

Strategies for Promoting Gender Equity

There are a clear and consistent set of strategies for promoting equity in the K–12 science classroom for girls and young women. These strategies are based on years of research and hold across grade levels, science content areas, and underrepresented and diverse students.

Science activities should be part of the pre-K/kindergarten curriculum to encourage curiosity, counter gender stereotyped behavior, and encourage science for free choice play. Young children need long term exploratory activities, multiple and varied opportunities to engage in science, especially out of doors, and open-ended activities. Teachers should ask questions of boys and girls equally, provide opportunities to talk about science experiences, and monitor discussions for equitable participation of boys and girls. Teachers should choose non-fiction literature in conjunction with science inquiry activities (e.g. books about plants and creating a school garden) to increase understanding and perceptions of girls as science learners.

Self-efficacy as a science learner is critical for achievement, persistence, and choosing a science career. Self-efficacy, in terms of feelings of mastery, can be increased by science-related activities that are at the right level of difficulty for successful completion and by hearing positive messages about competence. Science peer role models also increases self-efficacy in science and foster a science identity. Reducing sex-based threats by providing low risk gender neutral activities also enhances self-efficacy and achievement in the critical years of middle school.

Appropriate curriculum and pedagogy promote gender equity and learning in classrooms. Teachers should use student centered active learning tasks, open ended real-world problems that address the concerns and interests of girls, collaborative work monitored for equitable male/female participation, and group discussions. Topics should be seen as useful, personally relevant, related to life in and out of school and to career interests. Avoid worksheets, cookbook labs, individual work, teacher centered lectures, abstract topics, and work that is inappropriately difficult because they fail to engage girls and promote interest and learning in science.

Culturally responsive curricula promote equity by building upon students' strengths, culture, and experiences. Inquiry skills of obtaining, evaluating, and communicating information fit well with culturally responsive pedagogy when inquiry reflects students' experiences and funds of knowledge such as analyzing the nutritional value of fast food and communicating results. A culturally responsive curriculum also supports problem solving and cyberlearning.

English language learners, struggle with the gap between every day and scientific language. Two strategies that have proven supportive in providing opportunities to learn and developing the skills of scientific discourse and argumentation among English language learners are pairing students for work and allowing talk in both the native language and English.

To address the Next Generation Science and Engineering Standards and to enhance achievement, especially among low achieving middle school African American girls, teachers should integrate designbased activities and tinkering into science. Activities such as building an electrical alarm system to learn about electricity fulfill both science and engineering standards and help develop an engineering identity for girls.

Not much is known about the impact of the flipped classroom in K–12 education so it is too new to recommend. Studies have mixed results and do not we know whether gender differences exist. What research exists reinforces what we already know. The design of materials and topics are critical components of on-line learning for girls. Girls prefer on-line discussions, connections to classroom activities, supportive feedback and time to finish assignments. Furthermore, it appears that how the teacher structures the in-class portion of instruction is more important for learning than the on-line component.

Summary

To support girls and women in K–12 science classrooms and promote equity focus on strategies grounded in research. Introduce science at an early age, choose real world personally and socially relevant topics, support working with peers and active learning, create a student-centered classroom, use culturally relevant activities, bridge the gap between every day and science language, and build self-efficacy with mastery experiences and role models.

References

Baker, Dale 2016. *Understanding Girls: Quantitative and Qualitative Research*. Rotterdam, the Netherlands: Sense Publishers.

Baker, Dale 2013. "What Works: Using Curriculum and Pedagogy to Increase Girls' Interest and Participation in Science." *Theory into Practice 52*: 14-20.

Brown, Julie 2017. "A Metasynthesis of the Complementarity of Culturally Responsive curriculum and Inquiry-Based Science Education in K–12 Settings: Implications for Advancing Equitable Science Teaching and Learning." *Journal of Research in Science Teaching 54*, no. 9: 1143-1173. Doi: 10.1002/tea.21401

Capobianco, Brenda, Heidi Diefes-Dux, Irene Mena and Jessica Weller 2011. "What is an engineer? Implications of elementary School Students' Conceptions for Engineering Education." *Journal of Engineering Education 100* no2: 304-328. http://www.jee.org

Carberry, Adam, and Dale R. Baker 2017. "The Impact of Culture on Engineering and Engineering Education." In *Cognition, Metacognition, and Culture in STEM Education,* edited by Yehudit Judy Dori, Zemira R. Mevarech, and Dale R. Baker, 217-240, Chaim: Switzerland: Springer.

Chen, So-Chen, Steven Young, and Chia-Chang Hsiao. 2015. "Exploring Student Perceptions, Learning Outcomes and Gender Differences in a Flipped Mathematics course." *British Journal of Educational Technology 27,* no 6: 1096-1112. doi :10.1111/bjet12278.

Crippen, Ken and Pavlo Antonenko. 2017. "Designing for Collaborative Problem solving in STEM Cyberlearning ." In *Cognition, Metacognition, and Culture in STEM Education,* edited by Yehudit Judy Dori, Zemira R. Mevarech, and Dale R. Baker, 89-116, Chaim: Switzerland: Springer.

Gonzalez-Howard, Maria and Katherine McNeill 2016. "Learning in Community of Practice: 148-164. Factors Impacting English-Learning Students' Engagement in Scientific Argumentation." *Journal of Research in Science Teaching 53* no 4: 527–553.

Jenen, Jaime, Tyler Kummer, and Patricia Godoy. 2015." Improvements From Flipped Classroom May Simply be the Fruits of Active Learning." *CBE-Life Sciences Education 1,* (March): 2-14. doi:10.1187/cbe14-08-129.

Lo, Chung Kuan and Khe Foo Hew. 2017. "A Critical Review of Flipped Classroom Challenges in K–12 Education: Possible Solutions and Recommendations for Future Research." *Research and Practice in Technology Education 12,* no. 41: Springer Open. https://doi.org/10.1186/s41039-016-0044-2.

References (continued)

Mehalik, Mathew, Yaron Doppelt, and Christian Schunn 2008. Middle-school science through design-based learning versus scripted inquiry: Better overall science concept learning and equity gap reduction. *Journal of Engineering Education, 97* no 1: 71–82.

National Science Teachers Association 2014. NSTA Position Statement Early Childhood Education. www.org/about/positions/early childhood.aspx

Patrick, Helen, Mantzicopoulos, Panayota, and Ala Samarapungavan 2009. "Motivation for learning science in kindergarten: Is there a gender gap and does integrated inquiry and literacy instruction make a difference?" *Journal of Research in Science Teaching 46* no 2: 166–191.

Vincent-Ruiz, Paulette and Christian Shunn 2017. "The Increasingly Important role of Science Competency Beliefs in Science Learning in Girls." *Journal of Research in Science Teaching, 56* no 6: 790-822.