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Abstract

Students with disabilities are underrepresented in science, technology, engineering and mathematics (STEM) careers (National Science Foundation, 2015). The underrepresentation is a problem because the nation's competitiveness depends on diverse individuals with STEM knowledge, skills, and abilities to drive innovation that will need to new products and economic growth (Business higher Education Forum/A Policy Brief, 2014; National Academies of Sciences, Engineering, and Medicine, 2016; National Science Board, 2016). The author discusses the importance of engaging students with disabilities in informal Science, Technology, Engineering, and Mathematics activities.

Keywords

extracurricular, clubs, STEM, disabilities, social skills, soft skills, informal, self-efficacy, self-determination

Importance of STEM Extracurricular Activities for Students with Disabilities

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Abstract: Students with disabilities are underrepresented in science, technology, engineering and mathematics (STEM) careers (National Science Foundation, 2015). The underrepresentation is a problem because the nation's competitiveness depends on diverse individuals with STEM knowledge, skills, and abilities to drive innovation that will need to new products and economic growth (Business-higher Education Forum/A Policy Brief, 2014; National Academies of Sciences, Engineering, and Medicine, 2016; National Science Board, 2016). The author discusses the importance of engaging students with disabilities in informal Science, Technology, Engineering, and Mathematics activities.

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The Importance of Extracurricular Activities for Students with Disabilities

All students, including students with disabilities (SWD) who participated in after-school programs that offer a variety of experiences develop skills and self-confidence (Kleinert, Miracle and Sheppard-Jones, 2007). These social and emotional skills are difficult to achieve in the typical classroom setting (Snellman, Silva, Frederick & Putnam, 2015). Kleinert and colleagues (2007) pointed out the Individuals with Disabilities Education Act (IDEA) requires schools to provide access to extracurricular activities and recommended participation in after-school programs is included in students' Individual Education Programs (IEPs). After-school clubs can integrate needed work place (soft skills, i.e. collaboration) and social skills interventions with students who share similar interests in a natural, informal, learning environment. Students with disabilities develop social competence by experiencing friendships and gaining valuable teamwork skills. These experiences are needed for many post high school jobs, especially in the STEM areas.

Extracurricular activities have been associated with improved academic performance and psychosocial development (Durlak, Weissberg, & Pacan, 2010). Students who participate in after-school activities have been positively linked to higher grades, test scores, school value, school engagement, and educational aspirations (Fredricks & Eccles, 2008). Additionally, participants have positive psychological benefits such as higher self-esteem, psychological resiliency, and lower rates of depression (Fredricks & Eccles, 2008). Moreover, some studies show a link to after-school club participation and lower dropout rates, delinquency, and substance abuse levels (e.g., Eccles & Barber, 1999; Mahoney, 2000; Mahoney & Cairns, 1997).

Science, Technology, Engineering, and Mathematics Education

In many countries, including the U. S., an economy based on the understanding of STEM is replacing traditional manufacturing (Kaku, 2011). Unfortunately, the U.S. is ranked 25th in science on the latest Program of International Student Assessment (Organization for Economic Cooperation and Development; OECD, 2016). Across the world there is clear evidence of a significant need for students who have an understanding of STEM and the diverse range of associated careers (National Science Board, 2016).

Science, technology, engineering and mathematics education plays a critical role in shaping culture and economic development through innovation (Cooper & Heaverlo, 2013). To be successful during STEM learning experiences, students must move beyond low-level cognitive tasks and gain a foundational understanding of the content (Marino, Gotch, Israel, Vasquez, Basham, & Becht, 2014). A meaningful STEM program encourages students to develop solutions that incorporate a variety of disciplines (Basham, Israel, & Maynard, 2010). Educators can create engaging learning environments where students are encouraged to identify and solve problems (Marino, Israel, Beecher, & Basham, 2014). Students' benefit when they work collaboratively to develop solutions across subject areas (Schroeder, Scott, Tolson, Huang, & Lee, 2007). Examples of STEM activities include robotics competitions (i.e. For Inspiration and Recognition of Science and Technology [FIRST], Best, Vex), STEM clubs (i.e. Science, Engineering, Communication, Mathematics, and Enrichment [SECME], science, engineering, coding), design challenges (i.e. solar car, astronaut), and STEM competitions (i.e. Science Olympiad, Math Olympics, Odyssey of the Mind).

Due to barriers to access STEM programs, SWD have been historically excluded from postsecondary STEM education (Burgstahler, 1994; Burgstahler & Chang, 2009; Moon, Todd, Morton, & Ivey, 2012). In fact, according to the U.S. Census data (2013), people with disabilities constitute 6% of the nation's general workforce, but only 2% of its STEM professionals. The reason for the exclusion is barriers that include reading levels of SWD, lack of inquiry and procedural skills, as well as lack of executive functioning skills. Therefore, it is imperative researchers and educators develop programs for SWD to overcome these barriers for SWD to participate in postsecondary STEM education.

Informal Science, Technology, Engineering, & Mathematics Learning

Denson, Haily, Stallworth, & Householder (2015) reported a need for reform in Science, Technology, Engineering, and Mathematics (STEM) education to attract a more diverse workforce. Watson and Froyd (2007) stated a diverse population in STEM careers impacted the level of creativity, innovation, and quality of STEM products and services. However, many STEM learning environments are formal and fail to introduce underrepresented students to STEM professions (Denson, Austin, & Hailey, 2013). Furthermore, researchers have recognized the importance of informal learning environments that will be instrumental to the reform of STEM education (National Research Council [NRC], 2015).

Chubin, May, and Babco (2005) postulated an effective informal learning environment in STEM must (a) promote awareness of engineering, (b) provide academic enrichment, (c) have trained and competent instructors, and (d) be supported by the educational system of the student participants. Informal learning environments are categorized into (a) everyday experiences, (b) designed settings, and (c) programmed settings (Kotys-Schwartz, Besterfield-Sacre, & Shuman (2011). As noted previously, informal learning environments typically take place outside of the traditional classroom environment and have been an integral part of education for years (NRC, 2015). Informal learning environments associated with school are often called extracurricular activities.

While science education often focuses on curriculum and teacher professional development, learning in non-school settings is often overlooked (Bell, Lewenstein, Shouse, & Feder, 2009). Every year millions of Americans explore informal learning institutions (i.e. science centers and museums) to pursue their interests (Bell et al., 2009). Informal science learning and community-based organizations include libraries, schools, think tanks, institutions of higher education, government agencies, private companies, and philanthropic foundations. Informal environments include a family discussion at home, visits to museums, nature centers, or other designed settings and every day activities like gardening. Informal learning environments include participation in clubs and recreational activities like hiking and fishing. Science enthusiasts who organize themselves into community-based organizations stimulate the science specific interests of students (Bell et al., 2009). As a result of the need for reform in STEM education, the Committee on Successful Out of School STEM Learning was established by the Board of Science Education to examine the potential of non-school settings for science learning (NRC, 2015).

The committee found evidence that individuals of all ages learn science across many venues. Furthermore, out of school programs have been shown to (a) contribute to student's interest in and understanding of STEM, (b) connect youth to adults to serve as mentors and role models, and (c) reduce the achievement gap by socioeconomic status (NRC, 2015). While the research is not robust enough to determine which programs work best for different types of students, the field of informal science learning research looks promising. The committee recommended programs that produce positive outcomes for learners are engaging, responsive, and make student connections (NRC, 2015).

Extracurricular Activities

There is a variation in activities offered in schools due to an increase in specialization and/or interest in specific types of extracurricular activities. Examples of school activities include sports, music, clubs, and/or religious activities (Adachi-Mejia, Gibson Chambers, Li, & Sargent, 2014). Extracurricular activities with a focus in STEM have become more popular due to an increase in young people's exposure and play an important role in influencing the trajectory of STEM learning for adolescents (Adams, Gupta, & Cotumaccio, 2014; Bell, Lwenstein, Shouse, & Feder, 2009).

Structured extracurricular activities as explained by Balyer and Gunduz (2012) included excursions, competitions, physical education, scouting, music, folklore, education/journal preparation, shows, theatre, fashion shows, exhibitions, chess, tennis, basketball, fair and creative drama. These activities are delivered inside or outside of school as a strategic tool to diminish negative behaviors. Extracurricular activities have a positive impact on student development and contribute to formal learning programs (Fredericks & Eccles 2006). Researchers revealed extracurricular activities have impacts on grades, exam results, and responsibility toward school, culture, socialization, motivation, positive attitudes toward school and educational eagerness (Darling, Caldwell, & Smith, 2008; Llyeras, 2008; Luthar, Shoum, & Brown, 2006; Fujita, 2006).

Additionally, researchers showed students developed and learned skills they enjoyed (Fredericks & Eccles, 2006; Shulruf, Tumen, & Tolley, 2008).

Extracurricular Activities and the Law

In 2013, the United States Department of Education, Office for Civil Rights issued guidance on school districts' legal obligation to provide SWD equal access to extracurricular athletic activities. According to Section 504 of the Rehabilitation Act, SWD have an equal opportunity to participate in extracurricular activities. However, in 2010 the U. S. Government Accountability Office (GAO) found many SWD were not given an equal opportunity to participate in extracurricular athletics (Galanter, 2013). Specifically, the authors of the GAO report (2010) stated, "Under the implementing regulations for both IDEA and Section 504, schools are required to provide students with disabilities equal opportunity for participation in extracurricular activities, which often include athletics" (p.2). The guidance is often interpreted to include extracurricular activities such as STEM clubs and hobbies (*Independent School District No. 12, Centennial v. Minnesota Department of Education, 2010*). Furthermore, IDEA (2004) Section 300.107(b) provides a non-exhaustive list of examples of extracurricular and nonacademic activities that expressly includes athletics, clubs, and activities offered by groups sponsored by the school district.

Self-Efficacy and Self-Determination in STEM.

In order to be successful in STEM careers, SWD must develop self-efficacy and self-determination skills. In 1997, Bandura wrote self-efficacy is the "belief in one's capabilities to organize and execute the course of action required to produce given attainment" (p.2). There are four factors to a students' sense of self-efficacy; mastery experiences, vicarious experiences, social persuasion, and self-management (Bandura, 1994). Additionally, positive prior experiences that result in positive outcomes increase confidence and willingness to persist when faced with challenges (Bandura, 1997; Schunk & Pajeres, 2009). Resilience, perseverance, and stress to perform a daunting task are reduced when a student sees a similar peer succeed through vicarious experiences (Bandura, 1997; Jenson, Petri, Day, Truman, & Duffy, 2011; Schunk & Pajares, 2009). Because self-efficacy beliefs are malleable, they can be changed through social persuasion (McNatt & Judge, 2008). Teachers, parents, and peers can boost confidence resulting in a student who is more likely to put forth and sustain greater effort

(Jenson et al., 2011). Within the field of STEM, SWD reported an increase in self-confidence when seeing other SWD succeed (Jenson et al., 2011). Organizers of after-school STEM activities can promote an increase in self-confidence by actively recruiting SWD to participate in their programs.

Not only is self-efficacy a problem for SWD, many SWD who wish to pursue postsecondary education in STEM need support in self-advocacy and self-determination skills (Grigal & Hart, 2010). Self-determination skills are needed to effectively advocate for needed accommodations (Izzo, Murray, Priest, & McArrell, 2011). Additionally, Test and colleagues (2009) found in a systematic review of the literature that self-determination skills in high schools were a predictor of post school education and independent living skills. Students with disabilities need to develop self-determination and self-advocacy skills to meet the demands of STEM degrees and careers (Izzo et al., 2011). Another skill needed by SWD to persist in STEM careers is soft skills.

Students with Disabilities Need Soft Skills to Succeed.

Special educators often deliver social skills instructions to change the behavior of students in self-contained environments (Miller, Lane, & Wehby, 2005). The skills are taught to students with disabilities by breaking the task down into steps then incorporating discussion, modeling, roleplaying, reinforcement, problem solving, and feedback (Elliott & Gresham, 2007). However, many teachers do not feel prepared to promote positive peer interactions (Dee, 2011). Within after-school STEM activities, coaches naturally promote positive interactions through teamwork and collaboration in a supportive environment. Thus, rather than prescriptive direct instruction using different types of curriculum, the goal of most STEM activities are team based competitions. The outcome is not an individual grade or accomplishment of an Individual Education Program goal or objective, but to win a competition or award in a natural environment.

Social skills in the workplace are often called soft skills. Robinson and Stubberud (2014) described soft skills as thinking in a creative way, thinking critically, networking, and working in teams to improve a program. Green and Blaszczynski (2012) described soft skills as personal qualities, habits, attitudes, and social graces that make someone compatible to work with and a good employee. Soft skills include teamwork, communication, leadership, customer service, and problem solving skills. According to De Ridder, Maysman, Oluwagbemi, and Abeel (2014) soft skills are defined as the social behaviors needed to become successful in the workplace. Attributes of soft skills include friendliness, empathy, and optimism (Heckman & Kautz, 2012). In other words, people who have a strong work ethic and work well in a team have soft skills. Soft skills are hard to acquire through reading and it is recommended they are learned through practice or informal learning environments. Informal learning environments like after-school STEM activities give SWD an environment to practice and generalize soft skills needed before transitioning to the workplace. Employers indicate soft skills are an important factor of job performance, if not more important than technical skills (Glenn, 2008). Soft skills are more difficult to teach and measure than technical skills (Loughry, Ohland, & Woehr, 2013). Industries hire individuals with strong soft skills in order to retain a competitive edge (Glenn, 2008). Employment in the United States has shifted and requires more employees to interact with others.

In STEM, successful students are not only problem solvers with high technical skills but are effective at soft skills like collaboration and communication (Brewer & Smith, 2011). Soft skills are so critical that 6 out of the 11 undergraduate student outcomes required by the Accreditation Board for Engineering and Technology (ABET) focus on soft skills (Williams, 2001). Given the importance of soft skills in the STEM workforce, it is surprising the engineering education research community does not give it more attention (Singer & Schweingruber, 2012).

Where do we go from here?

Students with disabilities are attracted to science activities like robotics (Howard & Park, 2014). Additionally, SWD often express unique attributes that are particularly beneficial to STEM careers (Basham & Marino, 2013). White and Mitchell (2013) pointed out these include:

1. Sustained, hypersensitive attention to detail
2. The ability to disassociate themselves from emotional attachment when completing tasks
3. Repetitive, systematic procedural knowledge and skills
4. The ability to conceptualize outcomes and solutions to complex STEM problems

Additionally, SWD depend on hands-on, inquiry-based instruction to access science content (Melber, 2004). Melber and Brown (2008) remind us that personally relevant topics are critical for engaging SWD in science learning. Maroney, Finson, Beaver, & Jenson, (2003) advocated for creating science experiences that make SWD feel emotionally safe and have the freedom to pursue investigations without unnecessary teacher evaluation or interference in the learning process. Falvey (2005) reported educators must believe (a) in student's capacities; (b) highlight student's strengths, gifts, and talents; and (c) SWD are competent in order for successful informal learning to take place.

To be successful in STEM careers, students must possess certain qualities. Some of these qualities include critical thinking, information literacy, reasoning and argumentation, innovative, flexible, takes initiative, appreciate diversity, reflective, communicate, collaborate, responsible and personable (NRC, 2012). Many students with disabilities exhibit strengths in several of these qualities including analytical aptitude as well as being creative with the ability to think outside the box. Students with disabilities exhibit several characteristics that will help them become successful in STEM occupations. Employers are recognizing these strengths by hiring more people with disabilities. Diversityinc.com's list of top 10 companies for hiring people with disabilities include STEM institutions like Ernst & Young, Accenture, Prudential Financial, Microsoft, AT&T, and IBM (2015). In 2016, 27 companies were recognized for exemplary hiring and employment practices for people with disabilities including Lockheed Martin, Boeing, Capital One, Northrup Grumman, and Prudential. Educators need to continue to provide innovative approaches such as extracurricular activities to address the skills deficits in students with disabilities who want to pursue STEM careers. One way to address the barriers to entry into STEM careers is by providing access through recruitment to STEM extracurricular activities to students with disabilities. Furthermore, SWD should be actively recruited to participate in STEM activities through strategies such as reverse inclusion whereby a club is formed for SWD using IDEA funding and students without disabilities would be allowed to participate.

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