

STEM LITERATURE REVIEW

Science Technology Engineering and Math, commonly referred to as STEM, has taken the education world by storm. There has been a push for emphasizing these subjects in the 21st century world to prepare students for careers in these fields through exploration, problem-solving, and inquiry (Asghar et al. 2012). Employment in STEM related fields are expected to increase by twice as much as all other career fields (NEEF 2015).

In order to teach these subjects effectively, active participation to acquire skills, not just knowledge, is crucial. This enhances real world applicability and helps tie connections to what STEM professionals do in their daily jobs (Caparo and Sough 2013). STEM professionals are regularly tasked with solving complex problems that have multiple solutions. It is important for students to develop the ability to identify possibilities and assess their strength and limitations (Caparo and Slough 2013). To accomplish this, an interdisciplinary approach to STEM can foster a better understanding and mastery of these concepts in their application to the real world, as those problems by nature are interdisciplinary (Asghar et al. 2012). This calls for schools to veer away from treating STEM subjects as siloed subjects (Asghar et al. 2012). Using project-based learning (PBL) as an approach to STEM answers this call and develops critical thinkers who will be more likely to succeed later in life, (Caparo and Slough 2013) as well as provide students with a wealth of learning gains that are discussed here.

STEM related PBL has been shown to drive student performance in school and create interest in STEM fields (Baumann 2013; Cichon & Ellis, 2003; Minstrell & van Zee, 2000; Schoen & Hirsch, 2003). Achievement gains have been shown to improve in a variety of specific STEM subjects. Significant improvement has been shown in statistics literacy (Koparan & Güven 2014), machine engineering (Rivet & Krajcik, 2004), math (Melchior 1998; NELS 1988), science (Marx et al. 2004; NELS 1988), and technological knowledge and skill (Mioduser & Betzer 2007). There have also been a wealth of research showing that it has generally affected student's learning in a positive manner more broadly as well (Baumann 2013; Davila and Mora 2007; Harris et al. 2014).

Interestingly, STEM PBL has shown to provide a variety of other benefits. For example, it has shown to help close the achievement gap, with lower-performing students exhibiting higher growth rates compared to their higher-performing peers (Han et al. 2015). It has also shown to increase collaborative and cooperative working habits among students (Koparan & Güven 2014), increase their ability to recall information, apply information in creative ways, and help students draw conclusions/ relationships between concepts (Rivet & Krajcik, 2004).

Not only do students gain knowledge and skills, they have empirically shown to become more motivated in school, in STEM subjects, and STEM related careers. Melchior (1998) found that students become more engaged at school and had better educational attitudes. Similarly, Baumann (2013) found significant effects on students' interest in STEM. Lastly, Tseng et al. (2013) found an impact on student's motivation and interest in STEM careers by participating in STEM PBL programs. Combined with these other findings, this approach to STEM education has a wealth of benefits to students.

The benefits are not only for students, educators also gain from using this STEM education methodology. Teachers who use these methods are more likely to use other high quality teaching strategies, like:

- cooperative learning
- integrating more technology in the classroom
- using primary resources
- connecting to the community (Billing et al. 2012)
- constructing their own explanations
- using models, investigations
- asking questions (Harris et al. 2014).

When educators attended professional development opportunities on this subject, they reasserted the need to make science instruction student-centered, inquiry-based, and to make it interdisciplinary to mimic real society (Smith and Liu 2014). This is of the utmost importance. Without educator buy-in, STEM PBLs cannot be executed well in the classroom.

Educators and students are in a partnership when carrying out a STEM PBL. The educator's role in implementation is different than traditional classroom instruction. Here, they are must be open to adaptation based on youth active participation (Han et al. 2013). Educators are more of a resource provider rather than a lecturer (Han et al. 2013). Students benefit greatly from this shift in STEM education in both knowledge and skill set. When done right, STEM PBLs are amazing educational tools that can prepare youth for the 21st century world.

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- STEM ties to PBL
 - Baumann 2013 both bullets
 - Koparan T, Güven B
 - Rivet, Krajcik
 - Davila and Mora 2007
 - Melchior 1998- bullet 2
 - Billing et al. (2012)- bullet 3
 - NELS 1988- bullet 1
 - Smith and Liu 2014- maybe both but probably just bullet 2
 - Harris et al. 2014- bullets 2,3
 - NEEF 2015
 - Caparo and Slough 2013
 - Tseng, KH., Chang, CC., Lou, SJ. et al. (2013)
 - Han, S., Capraro, R. & Capraro, M.M. (2015)
 - Han S, Yalvic B, Capraro M.M. and Capraro RM. (2013)
 - Asghar et al. 2012
 - Cichon & Ellis, 2003
 - Minstrell & van Zee, 2000
 - Schoen & Hirsch, 2003
 - Marx et al. 2004
 - Mioduser & Betzer (2007)