Technology and Engineering bring STEM to Life!
International Technology and Engineering Educators Association

Benefits of Technology and Engineering Education
Talking Points - Support

As we have seen, the Learn Better by Doing (LBbD) Study provides the basis for many talking points supporting the benefits and importance of technology and engineering education. Talking points will suffice to start a discussion but it will be necessary to provide evidence to back-up each of those points. This document is a supplement to the Talking Points document, providing evidence to each point listed in that document.

This document presents information in the following manner: 1) identifies each talking point, 2) specifies the LBbD Final Report page on which the point can be found, and 3) provides references, containing hyperlinks, that provide evidence to each LBbD finding/statement.

Note: In order to limit the size of this document it will identify two or three references for each point. Much more evidence may be gleaned from the *Technology and Engineering Teacher* journal and the *Journal of Technology Education*. The reader is encouraged to review both journals, and other provided references to find more supporting evidence, if desired. Additional resources can be found at the ITEEA Research on Teaching and Learning webpage.

Point One: Teachers feel that students learn by doing hands-on activities in their classrooms and students are doing more hands-on activities in technology and engineering classrooms (pp. 6-7).

Where science and mathematics teachers/courses may not have the time and available resources (p. 6), technology and engineering courses provide students opportunities to learn using the three domains of learning: Cognitive, Affective, and Psychomotor.

- Cognitive: Technology and engineering lessons and activities **easily applies science, technology, engineering, mathematics, language arts, social studies, and other content** (p. 6-7).

  References Supporting Point One (Cognitive Learning):

  TET: Fujiwara, Y. (2018, May/June). STEM integration: Solids, CAD, and 3D printers. *Technology and Engineering Teacher 77*(8), pp. 5-9. (Identifies learning AP Calculus and NGSS Engineering, Technology, and Application of Science).

  TET: Klink, P., Loveland, T. (2015, November). Vocabulary development in technology and engineering education. *Technology and Engineering Teacher* 75(3), pp. 8-13. (Students can participate in a variety of vocabulary-development activities to deepen their understanding of technical word meanings as they relate to technology and engineering education).

  TET: Grubbs, M. E., Grubbs, S. (2015, December/January). Beyond science and math: Integrating geography education. *Technology and Engineering Teacher, 74*(4), 17-21. (A World Geography and Technology teacher collaborates to align their units through overlapping concepts that appeared at "natural intersections" of the learning process).

- Affective: Technology and engineering courses provide students with opportunities to **work in teams**. Teamwork may help students develop positive attitudes and self-esteem. The 49th Phi Delta Kappan/Gallup Poll of Public's Attitudes Towards the Public Schools found that 82% of Americans, "feel that taking technology and engineering classes and developing interpersonal skills are the two most important aspects of school quality" (p.3). Technology and engineering students frequently work in teams, using engineering design processes to consider how they would solve real-world problems.

References Supporting Point One (Affective Learning):

TET: Blue, C., Mupinga, D., Ernst, J., Clark, A., DeLuca, V. W., Kelly, D. (2018, April). Premiere PD: Multiculturalism in the classroom. *Technology and Engineering Teacher, 77*(7), pp. 25-31. (In a succession of group activities over time, adopting a process of random selection of group membership and scaffolding of content is a proven methodology for developing within-group and group-to-group learning activities that ensure group diversity.)

TET: Mentzer, N. (2014, November). Holding Students Accountable in Team Projects. *Technology and Engineering Teacher, 74*(3), pp. 14-20. (Describes an efficient peer evaluation process that can be implemented at the middle and high school levels).

TET: Luna, E. A., Ernst, J. V., Clark, V., DeLuca, V. W., Kelly, D. (2018, March). Premiere PD: Enhancing classroom creativity. *Technology and Engineering Teacher*, 77(6), pp. 26-31. (The ability to think creatively and work in teams have both become defining skills sought after by businesses. Educational institutions can fulfill these needs by building these skill sets in their students.)

- Psychomotor: Technology and engineering courses provide students with opportunities to use **hands-on activities**, exercising their creativity and problem-solving skills in effort to solve-real world problems (pp. 7-9).

References Supporting Point One (Psychomotor):

TET: Hemming, J. (2018, April). RITE. Drawbridge by design: Civil engineering for middle school. *Technology and Engineering Teacher, 77*(7), pp. 40-44. (With *Next Generation Science Standards* including engineering goals, science programs have had to take a look at what is taught and what student's experience).

JTE: Ernst, J. V., Clark, A., C. (2009). Technology-Based Content through Virtual and Physical Modeling: A National Research Study. *Journal of Technology Education, 20*(2). (A study of technology-based content and the application of conceptual modeling, data-driven visualizations, physical modeling, and presentations simultaneously promote technological, technical, and visual literacy).

Point Two: Quoting the Phi Delta Kappa 49th Poll of Public's Attitude Towards the Public Schools, "Students need to take more technology and engineering courses to prepare them for life" (p. 3).

References Supporting Point Two:

2017 PDK Poll found that 82% of U.S. Adults surveyed feel that public school students should take more technology and engineering courses.

TET**:** Hacker, M., Crismond D., Hecht, D., Lomask, M. (2017, November). Engineering for All: A Middle School Program to Introduce Students to Engineering as a Potential Social Good. *Technology and Engineering Teacher*, *77*(3), pp. 8-14. (Middle school students learn engineering, not only as a career path, but as an endeavor with potential for doing social good).

Point Three: Students in science, technology, engineering, and mathematics classes do activities that address the same national standards (*Standards for Technological Literacy* (*STL*), *Next Generation Science Standards* (NGSS), and *Common Core State Standards for Mathematics* (CCSSfM) in their courses. However, technology and engineering students are completing what could be considered STEM activities more frequently than are science and mathematics students (pp. 6-7). Students not enrolled in technology and engineering courses are missing opportunities to use hands-on activities that bring STEM to life.

References Supporting Point Three:

TET: Wu-Rorrer, R. (2017, October). Filling the Gap: Integrating STEM into Career and Technical Education Middle School Programs. *Technology and Engineering Teacher*, *77*(2), pp. 8-15. (The field of STEM education is an educational framework that has surged in application over the past decade. Science, Technology, Engineering, and Mathematics (STEM) is infused in nearly every facet of our society. The central strength to the current CTE and academic integration efforts has been linking learned academic knowledge and skills directly with authentic applications).

TET: Hughes, W., Mona, L., Wilson, G., McAninch, S., Seamans, J., Stout, H. (2017, September). An Object in Motion: An Integrative STEM Approach to Accelerating Students' Interest in Newton's Laws of Motion. *Technology and Engineering Teacher*, *77*(1), pp. 10-16. (An integrative STEM approach to accelerating students' interest in Newton's Laws of Motion).

Point Four: Elementary Students Learn Engineering Design by Planning and Using Tools to Manipulate Materials.

References Supporting Point Four:

Elementary STEM Council: The Elementary STEM Council is an affiliate council of the International Technology and Engineering Educators Association (ITEEA). The Elementary STEM Council promotes technology education in the elementary school by supporting teachers with instructional materials and in-service monographs, workshops and technology activity curriculum packages.
The Elementary STEM Journal   Follow ESC on Facebook.

ITEEA Elementary STEM Council – Innovative Design Challenge.
ITEEA's Elementary STEM Council is sponsoring the *Global Design Challenge for Elementary STEM (GDC)* to provide students with a chance to solve a real problem and show the world that everyone can help find solutions to these global challenges.

TET: Wright, G. A., Jones, M.D. (2018, February). Innovation in the elementary classroom. *Technology and Engineering Teacher, 77*(5), pp. 8-13. (Outlines an innovation curriculum that can be taught to elementary-aged students to expand their creative and innovative abilities and potential).

JTE: Kelley, T., Euisuk, S. (2017). Examining Elementary School Students' Transfer of Learning Through Engineering Design. Using Think-Aloud Protocol Analysis. *Journal of Technology Education, 28*(2). (Research findings indicate that participants increased the amount of time spent on mathematical thinking by 34% when given a math-specific design task. Pre-and post-tests showed that participants gained significant science content knowledge).

Point Five: The literature tells us that scientists, technologists, engineers, and mathematicians use some form of engineering design process to solve problems. The engineering design process involves determining and solving problems, many times by designing and making prototypes or models. Elementary students who learn and use an engineering design process will be able to use this method of doing to guide them in their future school and life experiences (pp. 7-8).

References Supporting Point Five:

TET: Wicklein, R.C. (April, 2006). Five good reasons for engineering as the focus for technology education. *The Technology Teacher*, 65(7), 25-29. The author identifies and explains the primary rationale for having the field of technology education to direct its focus on engineering process.

JTE: Lammi, M., Becker, K. (2013). Engineering Design Thinking. *Journal of Technology Education, 24*(2). Design is often complex, involving multiple levels of interacting components within a system that may be nested within or connected to other systems. Systems thinking is an essential facet of engineering design cognition).

Point Six: Designing and modeling are key components in an engineering design process. By using a design process, students, "can integrate various skills and types of thinking—analytical and synthetic" (p. 8). An engineering design process is a tool used by engineers, scientists, etc. Students enrolled in technology and engineering courses have more exposure to and learn by using engineering design processes. This exposure provides students with opportunities to learn and practice this valuable problem-solving tool (p. 9).

References Supporting Point Six:

TET: Mentzer, N., Farrington, S., Tennenhouse, J. (2015, May/June). Strategies for Teaching Brainstorming in Design Education. *Technology and Engineering Teacher,74*(8), pp. 8-13. (Six brainstorming techniques are discussed along with how students are evaluated in applying the techniques).

***JTE*:** Cameron, D., Lammi, M. (2014). Building a Framework for Engineering Design Experiences in High School. *Journal of Technology Education, 26*(1). (The teaching of engineering design at the secondary level can help students develop critical–thinking and teambuilding skills and provides a platform for the integration of science, technology, engineering, and mathematics (STEM) subjects).

JTE: Lammi, M., Becker, K. (2013). Engineering Design Thinking. *Journal of Technology Education, 24*(2). (Design is often complex, involving multiple levels of interacting components within a system that may be nested within or connected to other systems. Systems thinking is an essential facet of engineering design cognition).

Point Seven: Technology and engineering activities promote female (as well as other students') interest and participation in STEM-related education and occupations. Research shows that female students enjoy studies and occupations that directly benefit society and/or individual needs and wants. Technology and engineering courses present students (male and female) with more interesting and challenging real-world scenarios involving societal and/or individual needs and wants (pp. 9-10).

References Supporting Point Seven:

TET: Brown, R., Ernst, J., Clark, A., DeLuca, W., Kelly, D. (2017, November). Engaging Females in STEM. *Technology and Engineering Teacher*, *77*(3), pp. 29-31. (Despite students' actual abilities in STEM, their self-perceptions can be the ultimate deciding factor in courses they choose to pursue).

TET: Milgram, D. (2011). How to Recruit Women and Girls to the Science, Technology, Engineering, and Math (STEM) Classroom. *The Technology Teacher*, November 2011, pp. 4-11. This article addresses the problem of low the number of females in STEM classes and offers suggestions as how to improve those numbers.

JTE: Weber, K. (2012) Gender Differences in Interest, Perceived Personal Capacity, and Participation in STEM-Related Activities. Journal of Technology Education, 24(1). (This research article provides an overview of student engagement, perceived personal capacity, and continuity, and describes the gender-related findings).

Point Eight: The LBbD Study found that the percentage of doing decreased from middle to high school in each content area during each year of this study. However, the percentage of doing decreased less in technology and engineering classrooms than it did in science and mathematics classrooms.

Many students become less interested in their studies while in high school. Could there be a correlation between the decrease of doing hands-on activities and students losing interest in school? If so, technology and engineering courses could help promote secondary education students' interest and academic success (pp. 9-10).

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References Supporting Point Eight:

National Research Council and the Institute of Medicine (NRC). (2004). *Engaging Schools: Fostering High School Students' Motivation to Learn*. Committee on Increasing High School Students' Engagement to Learn. Board on Children, Youth, and Families, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press. (In a 1997 survey, 67% of the high school students surveyed said that they "would learn a lot more if their teachers used hands-on projects and class discussion).

Hammond, C., Linton, D., Smink, J., & Drew, S. (2007). Dropout Risk Factors and Exemplary Programs: A Technical Report. Clemson, SC: National Dropout Prevention Center, Communities in Schools, Inc. (In a 2006 national survey, the most common reason given by dropouts for leaving school was that their classes were not interesting).