feature article

learn better by doing study—third-year results*

Students learn better by doing. At least that is what elementary and secondary science, technology, engineering, and mathematics teachers think. This is the fourth report discussing the Learn Better by Doing study. The first report (Round 1) (Moye, Dugger, & Starkweather, 2014a) introduced the study, defined "doing" in the context of this study, described why "doing" in the classroom is important, why there is a need for this study, and also provided selected findings from the first round of surveys. The second report (Moye, Dugger, & Starkweather, 2014b) identified the methods used and results of the first-round data. Round two (Moye, Dugger, & Starkweather, 2015) provided the number and percentages of responses and selected findings. This report presents the data found in rounds one, two, and three and provides information concerning the future of this four-round study.

The purpose of this study is to determine the extent to which U.S. public school students are doing hands-on activities in their classrooms. This study asks elementary and secondary (middle and high school) science, technology, engineering, and mathematics (STEM) teachers to respond to 13 statements concerning students "doing" in their classrooms. The first two statements are general in nature and are used for all grade levels. The remaining 11 statements are grade-level specific and based on *Next Generation Science Standards* (Achieve, 2013a; 2013b), *Standards for Technological Literacy* (ITEA/ITEEA, 2000/2002/2007), and *Common Core State Standards for Mathematics* (CCSSO, 2010). This report presents data collected from the first three of four rounds of the Learn Better by Doing study. Once the data from all four years are collected, the researchers will publish a final report, which will include the four rounds of data, implications of the results, and recommendations. Due to space limitations, the details concerning the methodology for this study are not described herein but can be found in Moye, Dugger, and Starkweather, 2014a and 2014b.

The researchers cast a very large net in order to gain as much participation as possible. In addition to over 30,000 emails sent to elementary and secondary science, technology, engineering, and mathematics teachers, the surveys were also promoted in the *STEM Connections* newsletter, ITEEA conference promotions, ITEEA website, and were available at a kiosk at the 2016 ITEEA Conference.

Findings

This round was open for teacher participation from July, 2015 until April 15, 2016. As in Rounds 1 and 2, teachers were asked to respond "Yes" or "No" to two general statements and 13 grade-level (elementary, middle, and high school) statements. The first general statement asked if teachers believe that students benefit from doing activities to support learning. The second statement asked teachers if they would assign their students more projects to do in class if they had the time and resources. A total of 1,050 eligible teachers responded to the two general statements. Of that number, 225 were elementary teachers, 270 secondary science, 298 sec-

***This research article is a result of an ITEEA/FTEE (Dugger/Gerrish endowment) research project.**

by Johnny Moye, DTE, William E. Dugger, Jr., DTE, and Kendall N. Starkweather, DTE

ondary technology and engineering, and 257 secondary mathematics teachers. Table 1 identifies the two general statements, the number of teachers who responded "Yes," the total number of responses, and percentage of "Yes" responses for both statements. Rounds 1 (2014), 2 (2015), and 3 (2016—this round), are included in the Table.

Table 1. General Statements, Number of "Yes" Responses/Total Responses, and Percentages of "Yes" Responses.

	Elementary "Yes"			MS & HS Science "Yes"			MS & HS Technology and Engineering "Yes"			MS & HS Math "Yes"		
Statement	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
1. I believe that students benefit from doing activities to support learning.	433/437 99.1%	296/296 100%	222/225 98.7%	399/404 98.8%	253/254 99.6%	270/270 100%	540/544 99.3%	601/605 99.3%	297/298 99.7%	282/285 98.9%	192/195 98.5%	257/257 100%
2. Given the time and resources, I would assign my students more projects to do in class.	422/437 96.6%	288/296 97.3%	221/223 99.1%	382/404 94.6%	242/254 95.3%	256/262 97.7%	515/544 94.7%	568/606 93.7%	284/298 95.3%	272/284 95.8%	177/195 90.8%	247/255 96.9%

One hundred fifty-five elementary teachers responded to Statements 3 through 13. At the elementary level, the percentage of doing in Round 1 was at 48%, and in Round 2, at 50.1%. During this round, the percentage of doing at the elementary level was 54.7%. Table 2 identifies elementary school Statements 3 through 13, the number of teachers who responded "Yes," the total number of respondents, and the percentage of teachers indicating "Yes" to each statement. Elementary-level data for Rounds 1, 2, and 3 are included. The last row of the table contains the number of "Yes" responses/total responses and percentages of doing in courses. The researchers derived the percentages by adding the number of "Yes" responses in the Elementary column and dividing that number by the total number of responses.

Table 2. Rounds 1, 2, and 3 Elementary School Statements, Number of "Yes" Responses/Total Responses, and Percentage of "Yes" Responses.

Statement	Elementary		
My students have...	**2014**	**2015**	**2016**
3. ...developed an object, tool, process or system that included several criteria for success and constraints on materials, time, or cost.	198/365 54.2%	133/243 54.7%	93/155 60%
4. ...constructed an object using the design process.	196/365 53.7%	138/243 56.8%	104/155 67.1%
5. ...designed and built a product or system.	174/365 47.7%	119/243 49%	94/155 60.6%
6. ...controlled variables to conduct an investigation that produced data serving as evidence.	222/365 60.8%	149/243 61.3%	92/155 59.4%
7. ...performed an activity to solve a design problem.	198/365 54.2%	145/243 59.7%	91/155 58.7%
8. ...generated and compared multiple solutions to a design problem, based on the criteria and constraints of that problem.	153/365 41.9%	116/243 47.7%	69/155 44.5%
9. ...built a model and then improved the design to better meet requirements.	170/356 46.6%	118/243 48.6%	84/155 54.2%
10. ...tested and evaluated solutions for a design problem.	157/365 43%	114/243 46.9%	80/155 51.6%
11. ...built and used a model to communicate their solutions to a problem.	162/365 44.4%	116/243 47.7%	84/155 54.2%
12. ...built something designed to meet specific criteria and constraints.	217/365 59.5%	131/243 53.9%	106/155 68.4%
13. ...used a computer program to model and simulate a solution to a problem.	80/365 21.9%	60/243 24.7%	35/155 22.6%
Total Yes Responses/Total Responses and Percentage of Doing in Courses	1927/4015 48%	1339/2673 50.1%	932/1705 54.7%

Three hundred three middle school teachers responded to Statements 3 through 13: 93 science, 126 technology and engineering, and 84 mathematics teachers. Table 3 identifies middle school Statements 3 through 13, the number of teachers who replied "Yes," the total number of responding teachers, and the percentage of teachers indicating "Yes" to each Statement. The last row of the Table contains the number of "Yes" responses/total responses and percentages of doing in courses. As with the elementary data, the researchers derived the percentages by adding the number of "Yes" responses in each column and dividing that number by the total number of responses in those columns.

Table 3. Rounds 1, 2, and 3 Middle School Statements, Number of "Yes" Responses/Total Responses, and Percentage of "Yes" Responses.

Statement	MS Science			MS Tech. & Engineering			MS Math		
My students have...	2014	2015	2016	2014	2015	2016	2014	2015	2016
3. ...developed a solution to be tested and then modified it on the basis of the test results.	94/133 70.7%	61/83 73.5%	62/93 66.7%	173/194 89.2%	192/218 88.1%	115/126 91.3%	49/104 47.1%	26/65 40.0%	45/84 55.6%
4. ...created a tool or model to address an individual or societal need or want.	51/133 38.3%	37/83 44.6%	33/93 35.5%	139/194 71.6%	161/218 73.9%	93/126 73.8%	18/104 17.3%	11/65 16.9%	14/84 16.7%
5. ...tested and evaluated a design in relation to pre-established requirements.	92/133 69.2%	64/83 77.1%	62/93 66.7%	177/194 91.2%	199/218 91.3%	113/126 89.7%	34/104 37.7%	21/65 32.3%	34/84 40.5%
6. ...made a model to test for solutions to a problem.	85/133 63.9%	65/83 78.3%	52/93 55.9%	169/194 87.1%	190/218 87.2%	105/126 83.3%	52/104 50%	28/65 43.1%	47/84 56%
7. ...completed an activity that demonstrated how humans use natural resources that have positive and negative short and long-term consequences.	71/133 53.4%	47/83 56.6%	39/93 41.9%	100/194 51.5%	119/218 54.6%	76/126 60.3%	18/104 17.3%	5/65 7.7%	11/84 13.1%
8. ...created a model by applying criteria and constraints.	90/133 67.7%	64/83 77.1%	57/93 61.3%	171/194 91.8%	202/218 92.7%	117/126 92.9%	46/104 44.2%	28/65 43.1%	38/84 45.2%
9. ...designed and used instruments to gather data.	92/133 69.2%	57/83 68.7%	54/93 58.1%	129/194 66.5%	144/218 66.1%	82/126 65.1%	47/104 45.2%	36/65 55.4%	41/84 48.8%
10. ...analyzed and interpreted data to determine similarities and differences in findings.	120/133 90.2%	79/83 95.2%	81/93 87.1%	146/194 75.3%	168/218 77.1%	100/126 79.4%	84/104 80.8%	52/65 80%	66/84 78.6%
11. ...solved a design problem by developing an object, tool, process, or system.	69/133 51.9%	47/83 56.6%	44/93 47.3%	165/194 85.1%	193/218 88.5%	112/126 88.9%	26/104 25%	15/65 23.1%	21/84 25%
12. ...performed an experiment to solve a design problem.	88/133 66.2%	60/83 72.3%	43/93 46.2%	137/194 70.6%	165/218 75.7%	104/126 82.5%	21/104 20.2%	19/65 29.2%	21/84 25%
13. ...identified the characteristics of a design that performed the best during a test process.	79/133 59.4%	58/83 69.9%	49/93 52.7%	158/194 81.4%	183/218 83.9%	102/126 81%	18/104 17.3%	12/65 18.5%	22/84 26.2%
Total Yes Responses/Total Responses, and Percentage of Doing in Courses	931/1463 63.6%	639/913 70%	576/1023 56.3%	1671/2134 78.3%	1916/2398 79.9%	1119/1386 80.7%	413/1144 36.1%	253/715 35.4%	360/924 39%

The data reveals that middle school students are doing more hands-on activities in technology and engineering courses than in science and mathematics courses. This point becomes more evident when viewing the data as depicted in Figure 1.

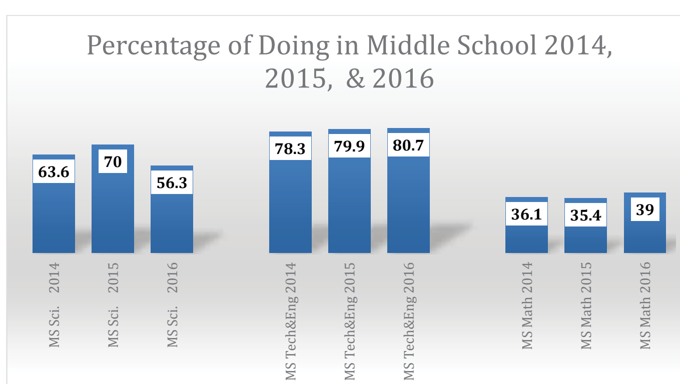

Figure 1. Rounds 1, 2, and 3 Percentage of Doing in Middle School Content Areas.

At the high school level, 386 teachers responded, of which 130 were science, 129 technology and engineering, and 127 mathematics. Table 4 identifies high school Statements 3 through 13, the number of teachers who responded "Yes," the total number of responding teachers, and the percentage of teachers indicating "Yes" to each statement. The last row of the table contains the number of "Yes" responses/total responses, and percentages of doing in courses. The researchers used the same method as with the elementary and middle school data to determine the percentage of doing at the high school level.

Table 4. Rounds 1, 2, and 3 High School Statements, Number of "Yes" Responses/Total Responses, and Percentage of "Yes" Responses.

Statement	HS Science			HS Tech. & Engineering			HS Math		
My students have...	2014	2015	2016	2014	2015	2016	2014	2015	2016
3. ...developed a solution to a complex real-world problem, based on scientific knowledge and student-generated sources of evidence.	111/220 50.5%	91/142 64.1%	77/130 59.2%	245/308 79.5%	269/325 82.8%	100/129 77.5%	68/151 45%	45/104 43.3%	61/127 48.0%
4. ...built a model of something to simulate the interactions between systems such as energy, matter, or information flow.	124/220 56.4%	95/142 66.9%	78/130 60%	217/308 70.5%	226/325 69.5%	93/129 72.1%	34/151 22.5%	23/104 22.1%	23/126 18.3%
5. ...created a presentation communicating the specifications and results of a design process used to meet a need.	90/220 40.9%	77/142 54.2%	76/130 58.5%	242/308 78.6%	257/325 79.1%	110/129 85.3%	52/151 34.4%	33/104 31.7%	39/126 31%
6. ...built a model using specified criteria and constraints.	154/220 70%	106/142 74.6%	91/130 70%	285/308 92.5%	298/325 91.7%	118/129 91.5%	70/151 46.4%	47/104 45.2%	56/126 44.4%
7. ...identified and applied criteria and constraints to develop a system or product.	94/220 42.7%	82/142 57.7%	68/130 52.3%	275/308 89.3%	283/325 87.1%	122/129 94.6%	54/151 35.8%	38/104 36.5%	47/126 37.3%
8. ...performed research to determine criteria and constraints driven by a societal problem.	96/220 43.6%	63/142 44.4%	68/130 52.3%	184/308 59.7%	190/325 58.5%	79/129 61.2%	40/151 26.5%	22/104 21.2%	22/126 17.5%
9. ...developed a solution to a major global challenge such as the need for improved health or supplies of clean water and food.	39/220 17.7%	31/142 21.8%	34/130 26.2%	80/308 26%	63/325 19.4%	34/129 26.4%	13/151 8.6%	3/104 2.9%	6/126 4.8%
10. ...applied the design process to evaluate an existing design or to collect data.	105/220 47.7%	86/142 60.6%	76/130 58.5%	239/308 77.6%	256/325 78.8%	105/129 81.4%	50/151 33.1%	30/104 28.8%	38/126 30.2%
11. ...built a prototype and checked it for quality and efficiency.	53/220 24.1%	49/142 34.5%	38/130 29.2%	247/308 80.2%	269/325 82.8%	110/129 85.3%	21/151 13.9%	17/104 16.3%	20/126 15.9%
12. ...used computer simulations to predict the effects of a design solution.	54/220 24.5%	41/142 28.9%	37/130 28.5%	168/308 54.5%	188/325 57.8%	83/129 64.3%	35/151 23.2%	15/104 14.4%	20/126 15.9%
13. ...evaluated a design solution by using conceptual, physical, or mathematical models to check for proper design.	44/220 20%	47/142 33.1%	38/130 29.2%	216/308 70.1%	223/325 68.6%	91/129 70.5%	42/151 27.8%	23/104 22.1%	28/126 22.2%
Total Yes Responses/Total Responses, and Percentage of Doing in Courses	964/2420 39.8%	768/1562 49.2%	681/1430 47.6%	2398/3388 70.8%	2522/3575 70.5%	1045/1419 73.6%	479/1661 28.8%	296/1144 25.9%	360/1386 26%

As with middle school, high school technology and engineering students are more frequently doing hands-on activities than are science and mathematics students. Figure 2 provides a graphic illustration of how high school technology and engineering students are learning by doing substantially more than are science and mathematics students.

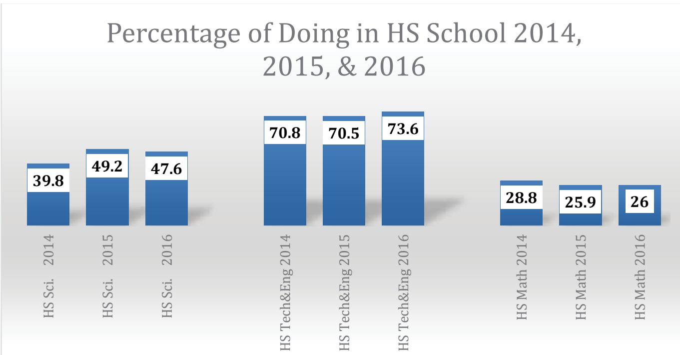

Figure 2. Rounds 1, 2, and 3 Percentage of Doing in High School Content Areas.

Determining the elementary and secondary percentage of doing is the focus of this study. Table 2 easily identifies the elementary percentage of doing, (2014 - 48%, 2015 - 50.1%, 2016 - 54.7%). In order to determine the secondary percentage of doing, the researchers combined the middle and high school data for each secondary level content area for each round/year. The combined percentage of doing in secondary science courses was 48.8%, in Round 1, 56.8% in Round 2, and 51.2% in this Round. The percentage of doing in technology and engineering courses was 73.6% in Round 1, 74.3% in Round 2, and 77.1% in this Round. As for students doing hands-on activities in mathematics courses, it was at 31.8% in Round 1, 29.5% in Round 2, and 31.2% in this Round. The combined secondary percentages bring to light a significant point—secondary technology and engineering students are learning by doing considerably more than are secondary science and mathematics students. Figure 3 shows the level of doing in secondary science, technology and engineering, and mathematics content areas in Rounds 1, 2, and 3.

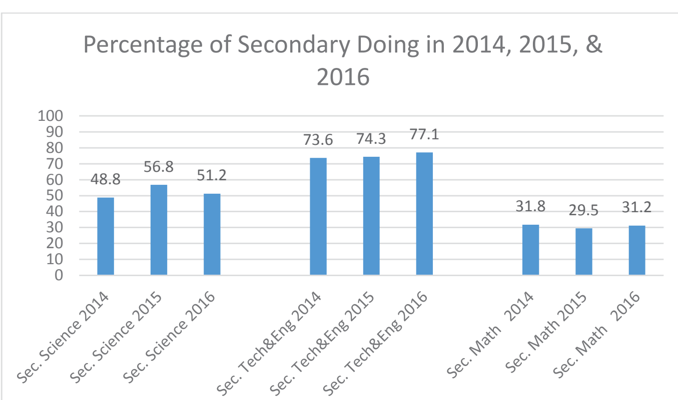

Figure 3. Rounds 1, 2, and 3 Secondary Percentage of Doing, by Content Area.

Discussion

When the researchers designed this study, they chose to identify the results of each round by calculating the percentage of doing versus using another higher-order statistical tool. This decision was made to simplify the ability for teachers to answer "Yes" or "No" to the statements as well as make it easy for decision makers to understand the methodology used to determine the level (percentage) of doing occurring in K-12 science, technology, engineering, and mathematics courses.

More middle school science and mathematics teachers and more high school mathematics teachers responded in this Round (2016) than in Round 2 (2015), but did not reach the number of responses in Round 1 (2014). This is an interesting point because the researchers sent five times the number of emails in this Round (over 30,000) than were sent in Rounds 1 and 2. The reason could be school divisions' use of spam programs to block unsolicited emails or emails from unrecognized addresses.

This round found that the vast majority of teachers feel that students benefit from doing activities to support learning, (elementary 98.7%, secondary science 100%, secondary technology and engineering 99.7%, and 100% of secondary mathematics teachers).

When asked if teachers would assign their students more projects to do in class if given the time and resources, they overwhelmingly indicated that they would. At the elementary level, 99.1% said "Yes," 97.7% secondary science, 95.3% technology and engineering, and 96.9% mathematics teachers indicated "Yes."

The results of the first two Statements indicate that classroom teachers feel that students learn better by doing.

The data show that for the third consecutive year, technology and engineering students are learning by doing more than are elementary and secondary science and mathematics students. When reviewing the three years of data, it shows that the lowest percentage of doing in secondary technology and engineering courses (73.6% in 2014) was almost 17 percentage points greater than the highest percentage of elementary or secondary science and mathematics content areas. The 2015 secondary science percentage (56.8%) was the percentage closest to the lowest technology and engineering percentage. This finding is very important. If students learn better by doing, as the vast majority of teachers suggest, then students who do not take technology and engineering courses are missing an opportunity to use hands-on activities to learn science and mathematics course content. Education leaders should recognize that learning by doing is a valuable resource, and it is occurring more frequently in technology and engineering classrooms.

For the third consecutive year, elementary teachers reported a higher percentage of doing than in the previous year (2014 - 48%, 2015 - 50.1%, 2016 - 54.7%). The percentage of doing in Round 3 increased in 7 of the elementary 11 statements. There was a decrease in four statements, but that decrease was no greater than 3.2% in any of those statements. Although the elementary percentages have varied somewhat, they have remained relatively consistent during the three rounds.

The researchers used two instruments to collect secondary (middle school and high school) information. Teachers were asked to respond "Yes" or "No" to 11 grade-level statements. These statements are based on *Standards for Technological Literacy* (ITEA/ITEEA, 2000/2002/2007), *Next Generation Science Standards* (Achieve, 2013a; 2013b), and *Common Core Standards for Mathematics* (CCSSO, 2010). Teachers in all three content areas agree (to some degree) that their students were doing the same kinds of activities in their classrooms. The data show that technology and engineering students do the same types of standards-based projects and activities (more frequently) than do science and mathematics students. Putting this point into perspective, technology and engineering students perform hands-on activities requiring the use of science and mathematics concepts more frequently than do science and mathematics students in those classrooms. Education leaders should investigate how to use their technology and engineering programs to improve overall science and mathematics student achievement.

With the exception of middle and high school science, the overall percentage of doing remained relatively the same in each content area in each round. In 2014 the percentage of doing in secondary science courses was at 48.8%. That percentage increased 8 percent (to 56.8%) in 2015, but in the 2016 round it decreased to 51.2% (2.4% higher than the 2014 percentage). This study is not designed to determine why percentages may vary. Round 4 will provide data that will help determine the average level of doing in secondary science courses. It should be noted that it has been three years since the publication of *Next Generation Science Standards* (Achieve, 2013a; 2013b). One of the purposes of *NGSS* is to increase engineering practice (doing) in the science classroom. Implementation of *NGSS* could have an impact on the percentage of doing in science classes.

The purpose of this study is to determine the extent to which U.S. public school students are doing activities in their classrooms. When examining the data more closely, there are many other interesting points (findings). For example, as previously noted, the percentage of doing in elementary classes has increased in each of the three rounds. The data show that over half of the elementary students use a design process in some way to develop an object, tool, process, or system dealing with constraints on materials, time, and cost. They engage in activities to construct objects to solve problems designed to meet specific criteria and constraints. It appears that, implicitly or explicitly, more than half of elementary students have been exposed to an engineering design process. Students therefore should be able to use this process at the secondary education level. This is an important point. *Standards for Technological Literacy* states, "The design process is a purposeful method of planning practical solutions to problems" (ITEA/ITEEA, 2000/2002/2007, p. 94). *Next Generation Science Standards* encourages teachers to raise "engineering design to the same level as scientific inquiry in science classroom instruction" (Achieve, 2013a, p. xiii). The *Common Core State Standards for Mathematics* document states, "The Standards of Mathematical Practice [or doing] describes varieties of expertise that mathematics educators at all levels should seek in their students" (CCSSO, 2010, p. 6). That practice is to include "problem solving, reasoning and proof, communication, representation, and connections" (CCSSO, 2016, p. 6). Secondary science and mathematics teachers expect their students to use some form of the engineering design process (e.g., doing or practice), but the data show they do not expect it as often as technology and engineering teachers do. The engineering design process may be new to science and mathematics teachers, but technology and engineering teachers have used this process as an instructional method—and their students have used it to perform hands-on activities to solve problems—for decades.

When comparing middle and high school data, it is interesting to find that the level (percent) of doing decreased from middle school to high school in each content area each year. With only one exception, technology and engineering showed a lower percentage of decrease than did either science or mathematics. In 2014 mathematics showed a 7.3% decrease, and technology and engineering a 7.5% decrease. As was previously noted, middle and high school technology and engineering students are doing more hands-on activities in their courses than are science and mathematics students. The data also reveals that the decrease of doing between middle and high school is not as extreme in technology and engineering programs when compared to science and mathematics programs. Many students become less interested while in high school (NRC-IM, 2004). Leaders should ask: Could there be a correlation between the amount of doing and student interest in school? Figure 4 provides an illustration of how the percentage of doing decreases between middle school (blue) and high school (red). The Figure also shows how doing in technology and engineering programs remains higher than in science and mathematics.

Presenting students with exciting and relevant activities is important to maintain their interest and participation. Research tells us that female students prefer studies and occupations that directly benefit society or individuals (Change the Equation, 2016; Eccles, 1994; NAE, 2008). In almost every incidence, statements concerning societal needs and wants received the lowest percentage of "Yes" responses at both the middle and high school levels.

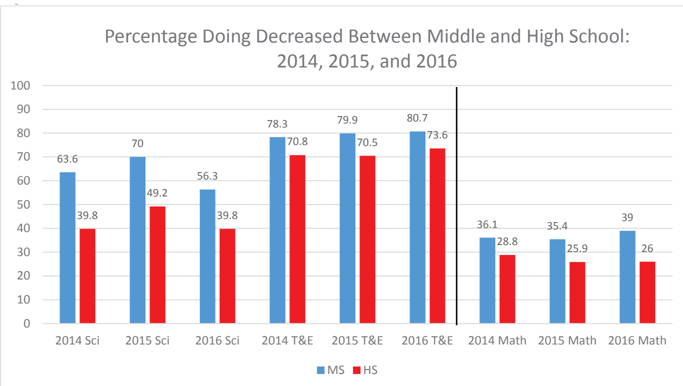

Figure 4. Level of Doing Decrease Between Middle and High Schools in each Content Area.

When compared to the other nine Statements, middle school Statements #4, (my students have created a tool or model to address an individual or societal need or want) and #7 (my students have completed an activity that demonstrated how humans use natural resources that have positive and negative short- and long-term consequences) received the lowest percentage of "Yes" responses in science and mathematics. When high school science and mathematics teachers responded to Statement #9, (my students have developed a solution to a major global challenge such as the need for improved health or supplies of clean water and food), they also gave it the lowest number of "Yes" responses in each possible incidence.

Technology and engineering teachers also indicated "Yes" less frequently to these three statements in the three rounds. However, technology and engineering teachers indicated "Yes" to MS Statement #4 at a higher percentage than science and mathematics teachers nine out of nine times, and seven out of nine times for MS Statement #7. At the high school level, technology and engineering teachers also indicated "Yes" to HS Statement #9 more frequently than science and mathematics teachers, 8 out of 9 times. The point here is that technology and engineering students did more hands-on activities focusing on societal needs and wants than did science and mathematics students. The *Vital Signs Report on the Condition of STEM Learning in the United States* tells us, "Educators who harness TEL's vision of literacy in technology and engineering may well attract many more girls to those fields" (Change the Equation, 2016, p. 9). If education leaders are interested in increasing female participation in STEM-related activities, continued education, and ultimately professions, those leaders should ensure that instruction and activities related to individual and societal areas are equally addressed in the classroom. Leaders should also note that technology and engineering students are performing these types of activities more frequently than are are science and mathematics students. Figure 5 compares the percentage of students participating in hands-on activities relating to individual and societal needs and wants, as described in MS Statements 4 (orange), 7 (blue), and HS Statement 9 (green).

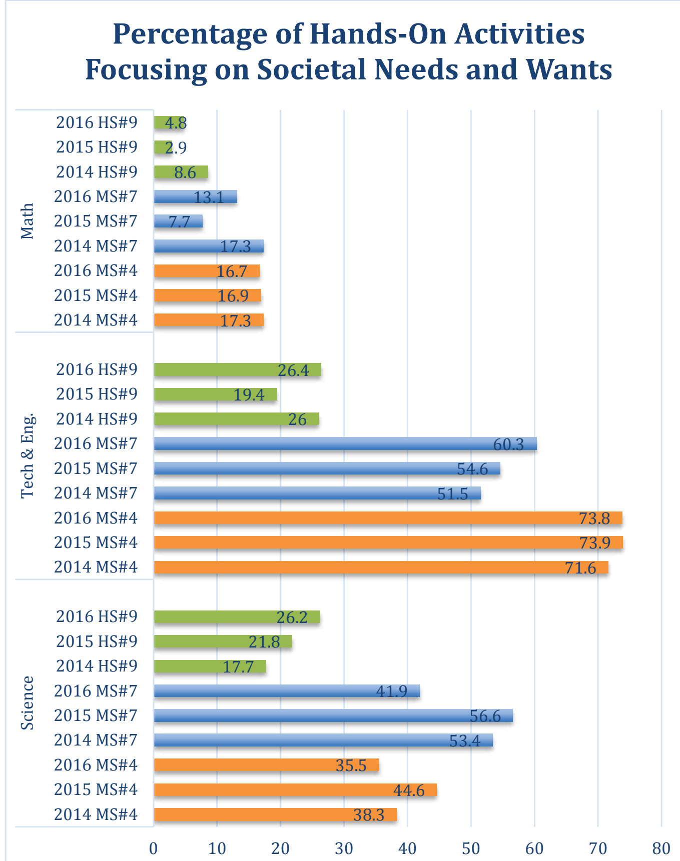

Figure 5. Statements and Percentages Focusing on Societal Needs and Wants

Summary

With the vast majority of teachers indicating that students learn better by doing, and the fact that students are doing more in technology and engineering courses, it stands to reason that technology and engineering courses are excellent resources to increase student achievement and better prepare them for continued education and the workplace.

This article identifies the results of the first three of four rounds of the Learn Better by Doing study. The researchers are currently conducting round four of this study. The survey instruments will be available until April 15, 2017. Using the same survey instruments and methods, the researchers will solicit input from as many elementary and secondary STEM teachers as possible. The results of the fourth round will be published in this journal. The researchers will also produce a Final Report containing the results of the four rounds, implications, and recommendations.

Elementary and secondary STEM teachers are encouraged to participate in this study, and can do so by following this link: www.iteea.org/Activities/2142/LearningbyDoingProject.aspx. Please feel free to contact the authors if there are any questions concerning this research study.

References

Achieve, Inc. (2013a). *Next generation science standards* (*NGSS*): *For states by states, (Vol. 1)*. Washington, DC: The National Academies Press.

Achieve, Inc. (2013b). *Next generation science standards* (*NGSS*): *For states by states, (Vol. 2)*. Washington, DC: The National Academies Press.

Change the Equation. (2016). *Vital signs: Reports on the condition of STEM learning in the U.S.* Retrieved from: http://changetheequation.org/left-to-chance

Council of State School Officers (CCSSO) and National Governors Association Center for Best Practices (NGA Center). (2010). Common core state standards initiative: Standards for mathematical practice. *Common Core State Standards for Mathematics* (*CCSS*). Washington, DC: Author.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Ecles, et al. of achievement related choices. *Psychology of Women Quarterly, 18*(4), 585-609.

International Technology Education Association (ITEA/ITEEA). (2000/2002/2007). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

Moye, J. J, Dugger, W. E., Jr., & Starkweather, K. N. (2014a). Learning by doing research introduction. *Technology and Engineering Teacher, 74*(1), 24-27.

Moye, J. J, Dugger, W. E., Jr., & Starkweather, K. N. (2014b). Is learning by doing important? A study of doing-based learning. T*echnology and Engineering Teacher 74*(3), 22-28.

Moye, J. J, Dugger, W. E., Jr., Starkweather, K. N. (2015). Learning by doing study: Analysis of second-year results. *Technology and Engineering Teacher, 75*(1), 18-25.

National Research Council and the Institute of Medicine (NRC-IM). (2004). *Engaging schools: Fostering high school students' motivation to learn*. Committee on Increasing High School Students' Engagement and Motivation to Learn. Board on Children, Youth, and Families, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Academy of Engineering. Committee on Public Understanding of Engineering Messages (NAE). (2008). *Changing the conversation: Messages for improving public understanding of engineering.* Washington, DC: National Academies Press.

Johnny J Moye, Ph.D., DTE *is a retired U.S. Navy Master Chief Petty Officer, a former high school technology teacher, and a recently retired school division CTE Supervisor. He currently serves as an adjunct professor with Old Dominion University's STEMPS department. He can be reached at johnnyjmoye@gmail.com.*

William E. Dugger, Jr., Ph.D., DTE *served as Director of ITEEA's Technology for All Americans Project, which developed the landmark* Standards for Technological Literacy *and* Advancing Excellence in Technological Literacy *documents. Dugger is an Emeritus Professor at Virginia Tech and serves as Senior Fellow for ITEEA. He can be reached at wdugger@iteea.org.*

Kendall N. Starkweather, Ph.D., DTE, CAE *is former Executive Director/CEO of ITEEA. His career has focused on advancing technology and engineering education worldwide as a teacher and teacher educator. He has worked for over three decades to determine direction and set policy for technology and engineering education at the national and international levels through association politics and policy. He is a distinguished graduate of the University of Maryland, a Distinguished Technology and Engineering Educator, and member of ITEEA's Academy of Fellows.*

Calling All STEM Teachers!

Are your public school students doing hands-on activities in your classroom? How many? How often?

The Learn Better by Doing Study needs YOU (even if you have participated before)!

The researchers are currently conducting Round 4 of this study, designed to determine the extent to which U.S. public school students are doing hands-on activities in their classrooms.

Elementary and secondary STEM teachers are encouraged to participate in this study by following this link: www.iteea.org/Activities/2142/LearningbyDoingProject.aspx. Participation deadline: April 15, 2017.