STEM Educators, How Diverse Disciplines Teach

Anne Lucietto Liza Russell Emily Schott
Purdue University

STEM (Science, Technology, Engineering, and Mathematics) is well known throughout the academe. Several studies have been done focusing on various aspects of students majoring in these disciplines, who they are, how they function, and the need to diversify the student and professional population. The authors realized that fewer studies are available that focus on educators that teach in the STEM disciplines. What research that does exist focuses on educators most often in a broad sense, and certainly not by differentiating by disciplines. When work is identified in this area, they seldom include a pervasive study of how these educators think, teach, and interact in the classroom.

To address this gap in research, a generalized survey requiring a large number of open-ended answers was developed with the intent of probing the population of STEM educators. Demographics were collected concerning the amount of formalized training, terminal degree, subjects taught, and where higher education began. The survey inquired about teaching philosophy and opinions about how STEM subjects should be taught. Additional information included educators' teaching experience (teaching), methodology, and the type of course taught.

Keywords: STEM, STEM educators, teaching, education, training, students, teaching style, teaching ability

Introduction

STEM is a group of disciplines consisting of focus in science, technology, engineering, and mathematics. This is a very broad base of courses and programs taught by a variety of educators (Gonzalez & Kuenzi, 2012). Individuals that teach and otherwise work with students on a daily basis influence them. Many of those that teach in this area are often confident of their abilities, while others are not (Nadelson et al., 2013). Educators that are confident provide positive reinforcement for students learning new and often difficult subject matter (Ejiwale, 2012), (Kennedy & Odell, 2014), (Eccles & Wang, 2015). Based on these findings, the questions asked of these educators are intended to probe the level of confidence they have in their ability to teach in a given field, how much education they have in this area, and other questions related to the educator and what they do.

Thus far, programs have been designed to aid STEM educators in the classroom (Sanders, 2008), and engage students (Kennedy & Odell, 2014), but little research has been done to understand the motivation and confidence of this population. Work that has been done is limited to discrete areas, generally focused on the various disciplines of STEM. While we do have an idea of who these educators are, understanding levels of education and how these educators teach will provide supporting information for future training and teaching of educators in the STEM disciplines.

Literature Review

The distinct disciplines of STEM (White, 2014) were originally grouped because these disciplines provide critical thinking skills that encourage students to solve problems within their area of study (White, 2014). The acronym originally came from policy first used by the National Science Foundation, where SMET was changed to STEM in 2001 (Breiner, Harkness, Johnson, & Koehler, 2012). Use of this term grew and has been recognized in educational reports since the 1980s (Breiner et al., 2012). Prior to this time, a variety of terms were used to indicate one was referring to the disciplines that are now referred to as STEM. While each of the disciplines differ, it is recognized that they are often intertwined – for example, math is studied in all areas of STEM, and other concepts such as physics, chemistry, and earth sciences are used as supporting knowledge in engineering and the fields consisting of technology (Labov, Reid, & Yamamoto, 2010).

Former studies provide guidance to STEM educators, including a plethora of teaching methods intended to engage students and motivate them to learn more about STEM disciplines (Roberts, 2013). The authors believe that without a clear understanding of STEM educators, especially their training, and their confidence levels, it is difficult to teach them how to teach and how to be engaging in the classroom. This, in turn, makes it difficult for these teachers to encourage the students to engage with the material and enjoy what is being taught. Limited literature exists on this subject. Therefore, with the established knowledge that STEM is an accepted grouping of disciplines, study of this body of educators was chosen.

Differences in education - fields, level of education, and skill levels - affect STEM educators in the classroom (Corlu, Capraro, & Capraro, 2014; Ejiwale, 2012; Nadelson et al., 2013), which in turn impacts confidence levels and overall teaching ability. This results in varying influences on students and the teachers' ability to motivate and engage students, both in and out of the classroom.

Pedagogy, Training, and STEM Educators. It is expected that K-12 educators be trained in education and the subject being taught. It appears that this is the case in the younger grades, but not necessarily in the higher grades. As noted previously, this is generally due to the availability and interest of the educators.

An analysis done by Ingersoll, Merrill, and May (2014) provided evidence that educators early in their career varied greatly in the education and preparation they received. They also found that the more mentoring and teaching education they received, the less likely they were to leave the profession. Further, they found that math and science educators had more subject-specific education and higher levels of education, but less preparation in methodologies and pedagogies than educators in other levels.

Sutcher, Darling-Hammond, & Carver-Thomas (2016) suggest that the supply of educators will become critical in the near future. Shortages at the higher levels of STEM educators are already being experienced. Furthering our understanding of who STEM educators are may provide a basis for developing better programs and targeted recruitment in the future.

Teaching of STEM Subjects. Faculty at the highest levels of education are often unprepared for the task of teaching (Figlio, Schapiro, & Soter, 2015; McKeachie & Svinicki, 2010). Rather, they are great researchers and are at the top of their fields, but lack the education and skills required to be successful in the classroom. Research shows that educators in the lower levels, such as P-6, are well trained as generalists and able to impart those subjects with which they are most familiar. As educators are examined at higher and higher levels, we find many that are well trained (Van Overschelde, 2013) and interested in working with their students to teach them how to be successful using the material they are learning, but we find many that do not like the subject and do a mediocre job in teaching it. It is becoming more apparent that graduate students need further training to help those that will go on to teach to become more effective and knowledgeable instructors. Initiatives have been executed to teach graduate students how to be effective teachers. Most of these programs are effective in the United States and other countries with similar educational systems (Patel, 2017). Patel (2017) explains that new doctoral students receive little to no pedagogical training and are then expected to teach undergraduate students. Some programs now incorporate training in pedagogy and classroom management into doctoral programs with the intent of aiding students when they are responsible for teaching in their own STEM classrooms (Griffin, 2016).

Learning in Lecture vs. Laboratory Environments. Mixed thoughts exist on lecture vs. laboratory learning. Many feel that lecture-type environments inhibit learning, particularly when flipping a classroom or having a large number of students (Deslauriers, Schelew, & Wieman, 2011). While both can be difficult, practitioners agree that using proven methods and research-based teaching tools provides the foundation for effective teaching in the classroom. When comparing lecture-based courses to laboratory-based courses that include newer techniques based on evidence of effective learning, different results emerge. Students are subsequently encouraged to learn at their own pace and in a way that works for them (Denick et al., 2013; Feder, Shouse, Lewenstein, & Bell, 2009; Mills, Knezek, & Khaddage, 2014).

Experienced educators, familiar with the material they are teaching, and possessing an understanding of how to teach various pedagogies and educational theory, are those that are most successful in using the results of educational research to work with students (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). These students successfully learn the material, are able to apply it, and accept the challenge to grow and learn more about the subject being studied (Wieman, 2014).

Educational Career. Research shows that those educators with more experience teaching are the most successful in teaching in new and different ways, incorporating research-based techniques in their classroom (Barr & Tagg, 1995). It appears, based upon these findings and others, that educators must have a significant amount of education and on-the-job-training to successfully navigate the variety of classrooms and learning environments that exist today. This often includes observation (Hebert & Worthy, 2001), time (Fisher et al., 1981), and understanding the students that they teach (Skinner, 2016).

Similarities/Differences Across STEM Majors. While there has been abundant work done recently on STEM students, it tends to focus on retention (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013; Wilson et al., 2012), recruitment (Wood, 2009), gender (Tyson, 2011; Wei, Jennifer, Shattuck, McCracken, & Blackorby, 2013), and racial (Cole & Espinoza, 2009) issues. Little has been done to understand the differences and similarities between students in STEM disciplines across majors. This study provides a starting point for this inquiry by asking the opinion of educators on the similarities across students in different STEM majors.

Teaching in Subjects Across STEM Majors: Research focused on STEM students, as they relate to each other, between the majors is lacking. Research on STEM educators teaching subjects across the majors is also lacking as a whole. Some research can be found focused on students (Graham et al., 2013) when centering on a specific discipline within STEM. In particular, in the sciences, such as life sciences (Wood, 2009) and physics (Tyson, 2011), technology is usually confounded by various majors and individual opinions on which majors are in the T of STEM. There is a lack of work in this area. Engineering research is easily found, but lacking in comparisons to other STEM fields, while mathematics studies are often isolated. A few studies have been found focused on topics such as STEM and students in the autism spectrum (Wei et al., 2013), but overall not found within the body of knowledge. This lack of information regarding teaching STEM majors – and the development of research in this area – leave many opportunities for expansion.

Research Questions

From experience, interacting with STEM educators across educational levels, the researchers noted that formal training, beliefs about teaching, and level taught did not seem to be connected. Further literature searches did not return information on these topics, so the researchers chose to discover whom STEM educators are, their background, and how they teach, thus asking the following:

- *How confident are STEM educators in their teaching of STEM subjects?*
- *How much education or training do they have in teaching STEM subjects?*
- *What is STEM educators' understanding of the best way to teach students?*

Methods

Due to the considerable amount of information needed about these educators, a three-part survey was devised using techniques listed by Blair (Blair, Czaja, & Blair, 2013), Fink (Fink, 2012), and Van Selm (Van Selm & Jankowski, 2006). The parts of this survey include: demographics, beliefs about teaching, and thoughts about STEM students.

Survey development. In the early stages of development, an outline was implemented to prevent overlap and provide direction leading to data related to research questions. While online surveys featuring open-ended questions are not always preferred, an understanding of this population necessitated their use (Van Selm & Jankowski, 2006). These open-ended questions allowed the researchers to gain a stronger insight into the population than multiple-choice questions would provide (Blair et al., 2013; Van Selm & Jankowski, 2006).

Collection Methods. Due to the need to interact with human subjects, the researchers obtained IRB (Institutional Review Board) approval and created a letter with details and a link to the survey. The link to the voluntary survey was distributed across a variety of professional teacher organizations, school districts, and personal network connections. An attempt was made to distribute the link over as wide an area as possible while covering science, technology, engineering, and math educators in equal numbers. All follow-up from connections was tracked.

Data Analysis Methodology. Initial outlines resulted in a 32-question survey, with responses gathered using an online Qualtrics survey. The five-week run time of the survey resulted in 211 "hits" with 201 usable responses. Thus, percentages in this work are based on the population size of 201, unless otherwise noted. After the close, Microsoft Excel was employed to analyze each question and identify basic trends in multiple-choice responses. Strong quotes from every question were marked for inclusion in this work. Finally, figures were prepared to visually represent trends and composition of the respondents.

Further analysis of the survey data was done using NVivo (QSR International, 2018) software. This was used to determine the common themes in the responses and the development of relationships within the data. Word frequency data was obtained, and for each of the three questions, the words are organized into a chart depicting the frequency of times each word was used in responses to the survey. The leftmost column of the chart contains the words that were used most frequently, with descending order of frequency as the words appear to the right. For clarity, the word frequency refers to the weighted percentage of the words as they appear in the survey responses.

Figure 1 (later in this work) was based upon the frequency data, and one pyramid represents one question and its corresponding responses. The top level of the pyramid contains a word that best represents the theme of the question. Each subsequent level contains words that appeared most frequently in responses, with the words appearing least frequently in the bottom level. Each pyramid has six levels, including five word groupings. For a word to appear in a pyramid in this paper, it must have a weighted frequency of 0.61% or more. Boxes between the pyramids have words common to the adjacent pyramid. For example, the word Communicate occurs in the pyramids for both the teaching and subjects' questions, and appears in the text box shown between those pyramids.

The three-dimensional comparison graph found in Figure 2 corresponds to the pyramid graphics that were constructed as previously noted. The bar heights for each word depict the frequency (weighted percentage) with which that word occurred in each question, allowing for comparison between themes apparent in the participant responses. The bars are color coded for each word based on the frequency used in survey responses. For example, all the words in the teaching graphic that are common between the teaching and subjects pyramids are colored differently from other word categories.

Survey Questions. This iteration of the survey is the first in what is intended to be a larger study of STEM educators and their beliefs. Therefore, the technique of using open-ended questions was employed to provide direction for future work. The nature of these questions allowed researchers to gain insight into unpredictable areas and allowed for more information than could be gleaned from a multiple-choice survey. The questions from the section of the survey covered here follow:

How They Teach

- Q1- How much formal training do you have in education?
- Q2 - What is your basic philosophy regarding how your subject should be taught?
- Q3 – How do you think STEM subjects should be taught?
  - o Q4-If you do not teach a STEM subject, should they be taught in the same way?
    - ▪ Q5-Why?
  - o Q6-If you teach a STEM subject, should they be taught in the same manner as your own?
    - ▪ Q7-Why?
- Q8-What kind of course do you teach? Lecture Only, Lecture/Lab, or Other?
- Q9- How long have you taught?
  - o Q10-If more than 5 years, have your teaching methods changed? Please describe.
- Q11-What methods do you use in your current teaching activities?

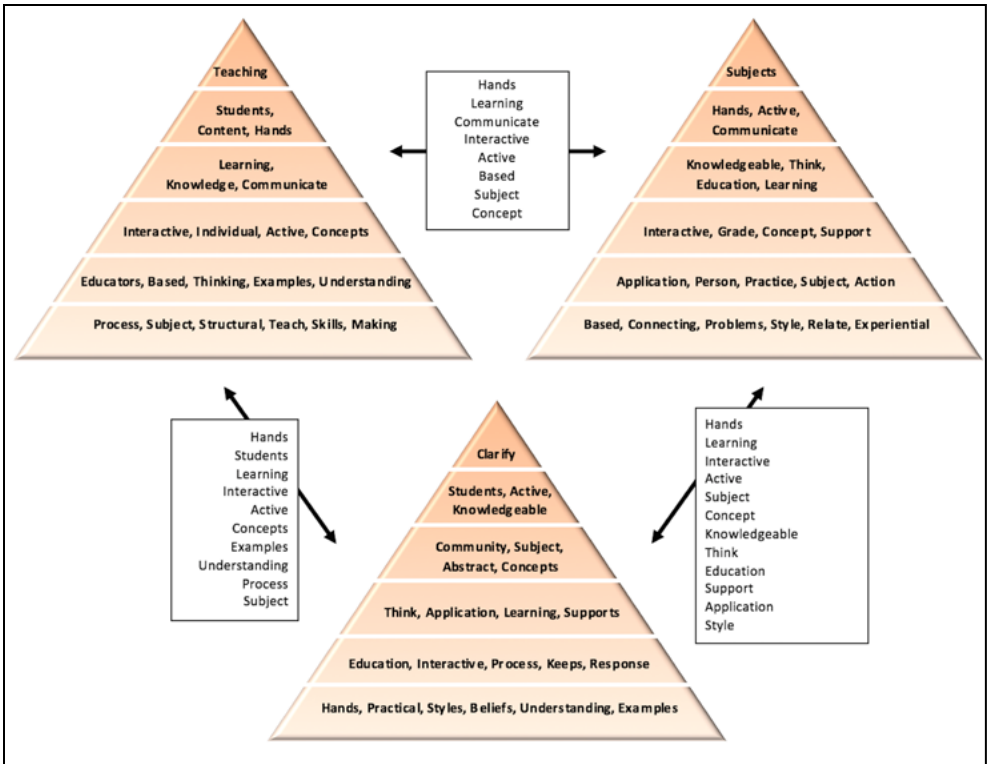

Figure 1. Intersection of Themes and Commonalities

Findings

Using the methods described above, three different areas were found in the participant responses: teaching, subjects, and clarifying thoughts. These are concepts addressed by the survey questions and show an intersection between frequently used words in each category. Figure 1 illustrates the weighted word frequencies within each of these themes and then compares similarities in answers of each area. Words such as hands-on, learning, and interactive are pervasive throughout the responses. These words are clearly identified in the boxes between each pyramid, providing the impression that these respondents were student-focused and believed that hands-on, interactive learning was the way to teach STEM subjects to their students.

Considering the Research Questions. The researchers intended to find how confident STEM educators were in their teaching of STEM subjects, how much education they have in teaching these subjects, and the best way to teach their particular students. The questions regarding confidence and the best way to teach were found using word frequency counts, and comparison of data from one area to the other. As the data was probed, researchers found that confidence often relies on the educators' level of knowledge, and their ability to convey the concepts to the students using active and hands-on techniques. The additional probing of the data provides an understanding that STEM educators are focused on what they know, how to communicate it, and supporting an interactive communication process with their students.

This also supports the answer to the third question raised to understand how they believe the subject should be taught. Figure 2 provides a comparison of the use of the

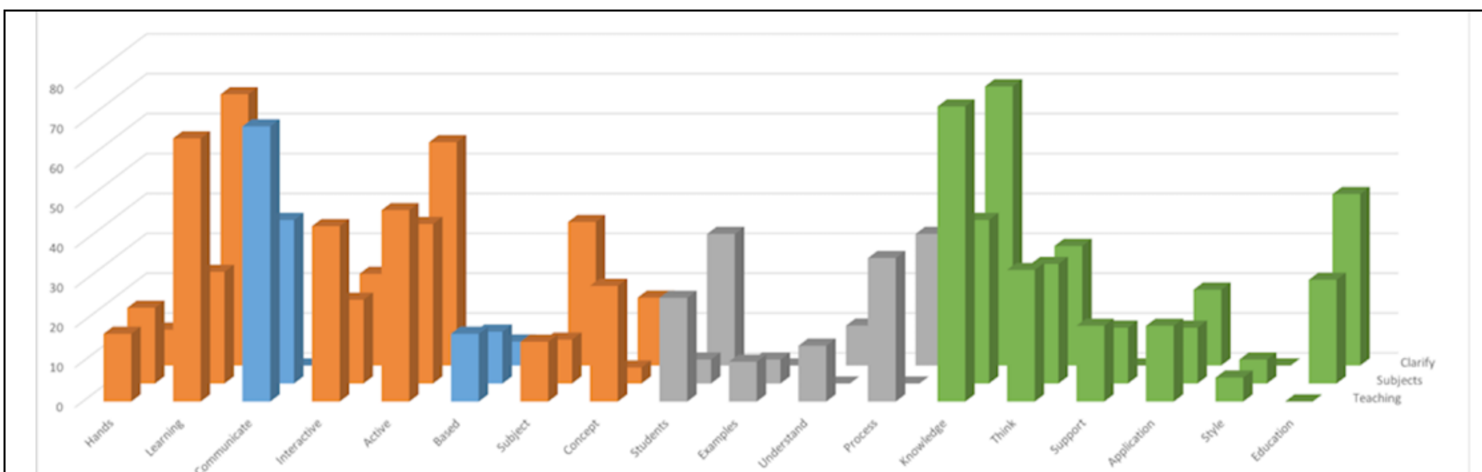

Figure 2. Word Frequency Weighted Averages: Teaching, Students, Clarify

words commonly found in Figure 1 and appearing in the boxes between pyramids. This is the weighted percentage of word usage pervasive throughout the participant responses considering the themes that are supported by the analysis summarized in Figure 1.

The second question, and further insight into the questions supported by these analysis methods follow.

Review of the Phrases and Supporting Statements. In looking at the whole survey, seventy-nine percent (79%) of respondents completed the entire survey, with the remaining twenty-one percent (21%) reaching various levels of completion. The initial questions were answered in greater numbers than the later ones.

How STEM Educators Teach. The second section of the survey focuses on how the responding STEM educators teach. These questions delve into the educators' formal training, their philosophy regarding teaching STEM courses, how they think those courses should be taught, and a background of what they teach and for how long.

Formal Education. At this point in the survey, the questions move into an educational focus. The first inquiry was to develop an understanding of how much formal education the STEM educators possessed. After review of the data, the responses were found to fall into one of three categories- educators with formal training, educators with a few courses/seminars/workshops, and those with no formal training.

Formal Training. For those educators with training, the length of that training varies from as little as 8 hours to 23 years. Based on the answers, for some educators, this includes classroom experience. "Formal training" was interpreted in a variety of ways. Some responding educators considered their degree their formal training, while others listed a few courses they took.

Few Courses/Seminars/Workshops. Others listed workshops, seminars, and individual courses. Some educators surveyed mentioned professional development sponsored by their school. Conferences also were mentioned and fall into this category.

No Formal Training. The educators responding with "no" training indicate that they did not receive any formalized training in teaching pedagogy before beginning their career as an educator. A few surveyed educators listed their degree as their training, but these are not the educators with education-specific degrees.

A few educators used an adjective to describe their training: "little to none," "minimal," "plenty," "good," or "extensive." Overall, the educators surveyed overwhelmingly stated that they had not received formal training in education as that was not part of their degree program.

How Students Should Be Taught. The consensus among responding educators is that teaching should be student-centered. Phrases such as "hands-on", "interactive", "practical", "active", "experiential", and "application" appeared frequently in responses to this question. One educator wrote "learning is more effective. . . when acquired by doing rather than by observing." STEM educators surveyed that believe in student-centered learning refer to themselves as "coaches" or as "guides" and often have industrial or government experience.

Traditional Methods. Some educators surveyed adhere to the traditional methods of lecture and educator-centered learning. These educators use words like "delivering" and utilize methods with terminology such as "solve on board, frequent quizzes." Another educator said, "it's up to the students to take advantage" of their learning environment. One quote represents the educators in this category: "My task is to present up-to-date material; the student's job is to engage in the learning process."

Simplifying Material. Answers to this question show that some responding educators simplify their material. For example, one said that they emphasize theory "without pushing too much higher mathematics on them." Others include a statement such as "Math and physics basics" or "firm basics," indicating they consider the foundation of the material they are teaching.

Learning As A Process. Other educators surveyed described learning as a process. They say, "hands-on after basic introduction," "Explain, Do, Consider," "design/prototype/build." The process seems to be theory-driven, allowing students to incorporate theory into reality, and then have them apply it to projects.

Preparing for Professional Position. Another category of educators surveyed is those who are focused on developing their students for the professional world. They say, "relate it to the future job," or "students are looking for a way to have a good career."

Every educator answered this a little differently. There were varied interpretations of "basic philosophy." An example of these responses includes, "We should be not "educators" but, rather, facilitators of learning, guiding students on their discovery of the subjects we present."

STEM Teaching Methods. Continuity exists regarding student-centered learning from the previous question. A good example of this idea is, "but at all levels, and for all subjects (not just STEM), I think education should be student-centered and interactive." There is specific emphasis on the real-world experience. One educator said in response to the question, "by people who have done the work in real-life, away from academia, get out of the textbook."

One educator is distinct in that he/she possesses a negative attitude towards educational catalogs and kits, stating, "The high school level should emulate real-world industries. The use of kits from the big educational catalogs does not serve high school level well." Another educator commented, "The way research determines is the most effective."

Many educators surveyed simply stated "see above" for the answer to this question.

Best Quotes Regarding Student-Centered Learning. "Student-centered learning rather than the sage on the stage," and "To me, that is what is so wonderful about STEM- most can be immediately applied for the student to better learn and then retain the information."

During the construction of the STEM educator survey, it was anticipated that some respondents will not teach STEM subjects. The next question asks if this is the case, do these educators believe that STEM students should all be taught in the same way.

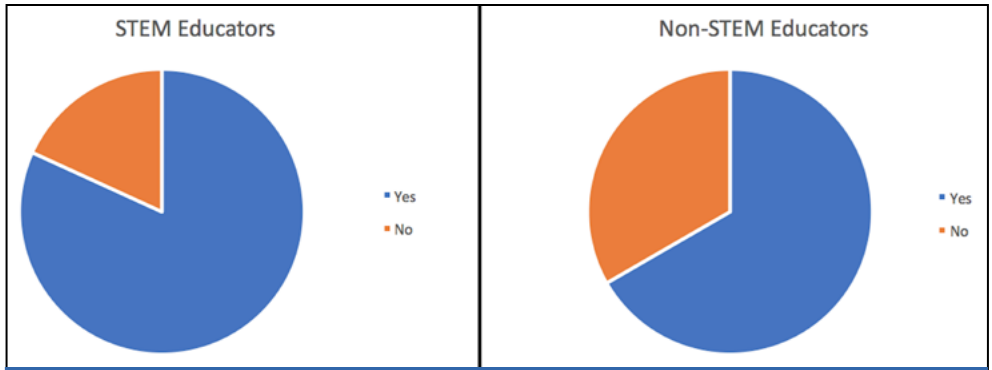

Figure 3. Should STEM Be Taught the Same Way?

Should All STEM Students Be Taught In The Same Manner? The question was directed at non-STEM educators; these respondents listed "other" as subject teaching. However, some STEM educators responded as well. Figure 3 shows the responses to this question, organized as STEM and non-STEM educators.

STEM Educators – Should all areas of STEM be taught the same? This question was directed at STEM educators. About 81.15% of respondents answered "yes" while the other 18.85% indicated "no." Respondents were asked to clarify their answer to the question "Should all STEM Courses be taught the same way?" The responses were separated into those that responded "no" and those that responded "yes" to the previous question. The following is a summary of those answers:

"Yes" Responses. The educators that said yes emphasize commonalities across the various disciplines of STEM. They indicate that "Hands-on experience connects everything together." They encourage their students to be "actively engaged in their learning, independent of the subject" and that they "should relate it with real-world applications." The educators generalize the idea of teaching,

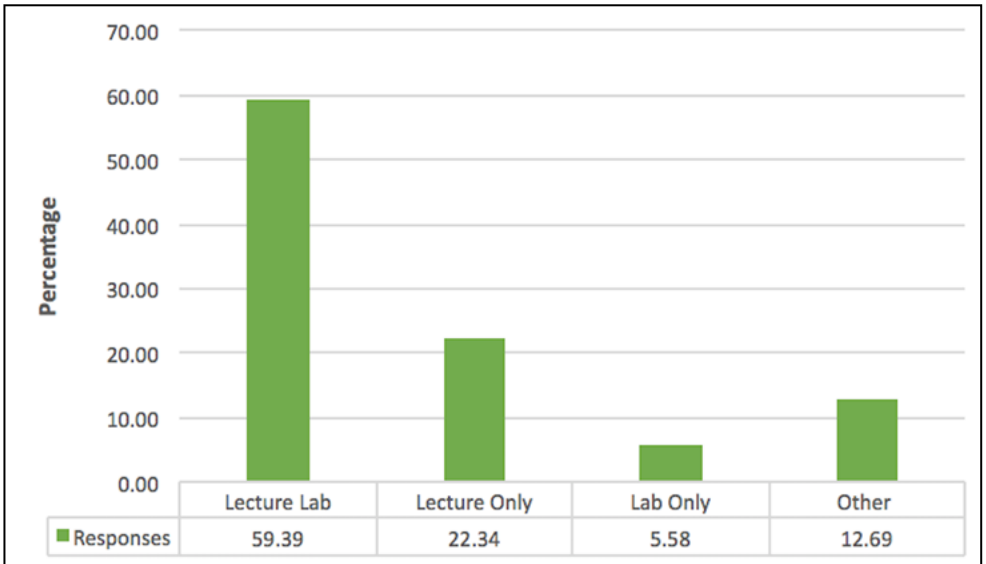

Figure 4. Which Type of Course is Taught

stating, "The general ideas of teaching and learning span many subjects." Others surveyed suggested that each class should be taught in the way best suited to the learner, the educator, and given facilities.

"No" Responses. These responding educators emphasized the differences between students and their learning styles. They suggested that these differences could be major related and thus teaching techniques should vary by discipline and by audience. Essentially, the characteristics and requirements of each discipline guides the teaching/learning techniques that should be employed. The response that reflected many of the educators answering no to this question was, "We should never assume a one-size-fits-all mentality."

To further the understanding of the survey population, the educators were asked to select the kind of course they teach. They were provided with the option to choose a Lecture/Lab, Lecture Only, Lab Only, or Other type course. Figure 4 shows the results, with the combined Lecture/Lab type course most prevalent. Respondents were given the option to select multiple answers for the variety of course given. The number of responses was totaled. The table indicates the percentage against all answers given.

Years Taught. Most of the responding educators taught for 16-20 years, with a significant percentage of educators having more than 26 years of experience. Figure 5 shows the responses to this question.

After asking the number of years taught by the respondents, they were asked if they had taught more than 5 years, and, if so, had their teaching methods changed. Approximately 70% of respondents indicated that their methods had changed, while 4% answered "no" and 27% did notrespond.

Changing Practices. Many educators surveyed mentioned refining their teaching methods but continued to use many of the same techniques. There is an emphasis on integrating technology and utilizing a flipped or virtual classroom. One educator stated, "We have evolved to Hybrid Classes." Another theme is narrowing the teaching to "Focus on learning rather than "coverage."

Some responding educators emphasize a move beyond hands-on learning to inquiry-based learning. One educator expresses this idea by writing, "I have gone from lecture and hands-on manipulative to inquiry-discover-based lessons." Other respondents stated that they changed their practices to allow the students to "fail without penalty" and "to do the "wrong" technique for longer. . . so they can learn from their mistakes."

Educators surveyed express the sentiment that their students are not as prepared as previous students. Two educators state, "I must also say that over this time period, I feel that the students' abilities (on average), especially in English and Math, have declined over the years" and "I simplify math because huge percentages of students cannot handle it." One educator sums up the drastic changes that have occurred: "My first class had 850 students in [a] dark room with overheads; I now use a virtual classroom where the students and I can each contribute to the board contents."

Some educators emphasize that times have not changed enough to alter their practices: "No, students start out knowing very little, so the things I did 30 years ago are still relevant."

Current Teaching Methods. There is not one most-frequently occurring teaching technique found in the responses. However, active learning and flipped classrooms were emphasized. Themes of project-based courses, teamwork, real-world experiences, capstone projects, and field work were present in the responses.

Many educators surveyed utilize practices that include "Shorter lecture followed by in-class lab time." Educators have a shorter lecture followed by time for students to work together on problems or projects. They also may employ a flipped classroom technique that allows the educator to use class time for problem-solving rather than lecture. Other responding educators express interest in utilizing technology, writing, "Mostly traditional lecture plus lab. I want to move to videotaping or accessing lecture which the students watch on their own time, and we work problems in class and lab."

A few still use traditional techniques: "Introduce topic in lecture, assign 5-10 related ungraded homework problems, assign 1-2 real-world application graded problems per week. . . pop quiz on topic. . . ."

Discussion

Earlier work indicates that most respondents were male, in their mid-50s and generally educators in engineering technology programs. The survey is limited due to the size of the survey respondents, and the timing of survey distribution. The result of open-ended questions are often difficult to interpret, as the analysis is reliant upon their interpretation. These questions were included

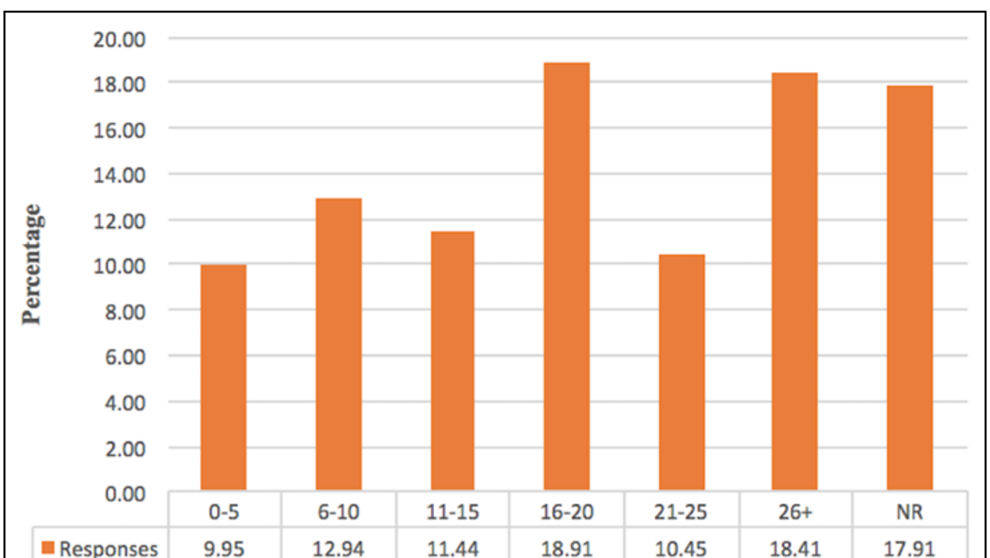

Figure 5. Number of Years Taught

in the survey with the intent of discovering areas that are unanticipated, and for future research.

The educators surveyed reported that their formal training in education ranges from an 8-hour workshop to their entire career. Some included informal training they have acquired in the classroom. Interpretation by the respondents on how to respond to the questions varied a great deal, providing evidence that respondents loosely interpreted the term "formal education." The data were sorted, and researchers found that those that reported a lack of training in education taught undergraduates in technology.

Some STEM educators surveyed refer to themselves as coaches and guides; these respondents generally have industrial/government experience and are focused on student-centered learning. They also report that they tailor their teaching to a student's response and rate of learning. Others surveyed, with little formal training, generally received their degrees 20-30 years ago, and use traditional assessment techniques, such as quizzes, and deliver the course material through lecture.

Responses from the STEM educators were sorted into four different categories: traditional, those that simplify material, learning as a process, and preparing students for a professional position. When asked about STEM teaching methods, those that responded that they believed in student-centric learning suggested that the methods used should be designed for the student. They also stated that teaching should be done by those that have real-life experience and can support the classroom experience with examples and applications.

Further analysis of responses resulted in the generation of word pyramids. This analysis visually showed connections between the educator's responses to different survey questions. The themes of teaching, subjects, and clarifying thoughts emerged.

Overall, nearly 80% of the STEM educators responding stated that STEM students can be taught the same as non-STEM students, while 67% of the non-STEM educators responding to the survey believed that to be the case. About 60% of respondents taught a combined lecture and lab for the same course and slightly over 22% taught lecture-only courses.

Of particular interest to the researchers is the distribution of years taught. No five-year grouping had less than 10%, with an even distribution of those reporting years taught. These educators are reporting that many of the students are less prepared than those they saw in years prior, particularly in math and English. There was no method of teaching that was more frequent than others, as responses varied from student-centered to educator-centered learning. While some education techniques can be considered to be in vogue, the educators surveyed here indicate that they do not necessarily follow the trends as shown by responses to teaching philosophy questions.

Conclusion

Overall, STEM educators surveyed believed that they had little to no formal training in how to be an educator, with those in technology teaching undergraduates reporting they have no training. Many of these educators reported that they did not feel they were well equipped to teach other disciplines, while they taught well and interacted with their students in a positive manner.

Based on responses gathered, future surveys need to include clear and concise questions regarding the type and length of formal training. Gathered responses indicated that the respondents defined formal training in different ways. Redistributing the survey will allow the researchers to add more to this data.

When the STEM educators responded to the survey regarding their preferred method of teaching, three categories of preferred teaching methods emerged. The first was traditional, focused on teaching in a very sterile, lecture-style format. Most often, the respondents indicating that this was their preferred method of teaching had little or no formal education training. The second method was to simplify the material for the students. This was fostered by the belief that learning is a process, and essentially indicated that there was some form of scaffolded learning emerging in this group. Finally, the last category was most evident in those STEM educators surveyed that had industry and/or government experience. They indicated that everything they do is geared towards preparing students for the professional positions they will hold throughout their career.

By analyzing word frequency, the researchers were able to glean that STEM educators believe that hands-on learning is integral to their student's success. Furthermore, the researchers determined that confidence relies on the educator's amount of knowledge and the ability to convey material to students using hands-on techniques.

Overall, this survey provided a look into educators teaching STEM disciplines, their own training and teaching abilities, as well as the manner in which they teach their students. It brought forward many new questions and provided insights into those individuals that teach STEM subjects and provided a focus for areas of new surveys.

Future Work. Additional comprehensive study of the STEM educator population in the United States may prove to be useful in our understanding of this unique population. An international study has the potential to further our understanding of those interacting with and coaching STEM students internationally. A study of this sort would provide insight into what works in other countries and what may be helpful to strengthen STEM education in the United States and worldwide.

References

Barr, R. B., & Tagg, J. (1995). From teaching to learning—A new paradigm for undergraduate education. *Change: The Magazine of Higher Learning, 27*(6), 12-26.

Blair, J., Czaja, R. F., & Blair, E. A. (2013). *Designing surveys: A guide to decisions and procedures:* Sage Publications.

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics, 112*(1), 3-11.

Cole, D. G., & Espinoza, A. (2009). When gender is considered: Racial ethnic minority students in STEM majors. *Journal of Women and Minorities in Science and Engineering, 15*(3).

Corlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: implications for educating our teachers for the age of innovation. *Egitim ve Bilim, 39*(171).

Denick, D., Dringenberg, E., Fayyaz, F., Nelson, L., Pitterson, N., Tolbert, D., . . . Cardella, M. (2013). STEM Thinking in Informal Environments: Integration and Recommendations for Formal Settings.

Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science, 332*(6031), 862-864.

Eccles, J. S., & Wang, M.-T. (2015). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development,* 0165025415616201.

Ejiwale, J. A. (2012). Facilitating teaching and learning across STEM fields. *Journal of STEM Education: Innovations and Research, 13*(3), 87.

Feder, M. A., Shouse, A. W., Lewenstein, B., & Bell, P. (2009). *Learning Science in Informal Environments:: People, Places, and Pursuits:* National Academies Press.

Figlio, D. N., Schapiro, M. O., & Soter, K. B. (2015). Are tenure track professors better teachers? *Review of Economics and Statistics, 97*(4), 715-724.

Fink, A. (2012). *How to conduct surveys: A step-by-step guide:* Sage Publications.

Fisher, C. W., Berliner, D. C., Filby, N. N., Marliave, R., Cahen, L. S., & Dishaw, M. M. (1981). Teaching behaviors, academic learning time, and student achievement: An overview. *The Journal of classroom interaction, 17*(1), 2-15.

Gasiewski, J. A., Eagan, M. K., Garcia, G. A., Hurtado, S., & Chang, M. J. (2012). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses. *Research in Higher education, 53*(2), 229-261.

Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer.*

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A.-B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science, 341*(6153), 1455-1456.

Griffin, M. P. (2016). TA Boot Camp: Ground-Breaking Training for University Teaching Assistants Debuts at Clarkson University [Press release]. Retrieved from http://www.clarkson.edu/news/2016/news-release_2016-07-21-3.html

Hebert, E., & Worthy, T. (2001). Does the first year of teaching have to be a bad one? A case study of success. *Teaching and teacher education, 17*(8), 897-911.

Ingersoll, R., Merrill, L., & May, H. (2014). What are the effects of teacher education and preparation on beginning teacher attrition?

Kennedy, T., & Odell, M. (2014). Engaging students in STEM education. *Science Education International, 25*(3), 246-258.

Labov, J. B., Reid, A. H., & Yamamoto, K. R. (2010). Integrated biology and undergraduate science education: a new biology education for the twenty-first century? *CBE-Life Sciences Education, 9*(1), 10-16.

McKeachie, W., & Svinicki, M. (2010). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers:* Cengage Learning.

Mills, L. A., Knezek, G., & Khaddage, F. (2014). Information Seeking, Information Sharing, and going mobile: Three bridges to informal learning. *Computers in Human Behavior, 32*, 324-334.

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research, 106*(2), 157-168.

NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 12, 2018.

Patel, V. (2017). Training Graduate Students to Be Effective Teachers. *The Chronical of Higher Education*. Retrieved from The Chronical of Higher Education website: http://www.chronicle.com/article/Training-Graduate-Students-to/240783?key=f15y8715k-1n0EpJg1p9khV9PwC2456TKAnihe3HOrToidG-P2s1mj4uYMH1gt8BrNdXUwVWtjaEFhYVRSb-Dc3T0tHWDl4akVYOVBBV2xzRXFVQTJWMWdN-Nm8xVQ

Roberts, A. (2013). STEM Is Here. Now What? *Technology and engineering Teacher, 73*(1), 22-27.

Sanders, M. E. (2008). Stem, stem education, stemmania.

Skinner, B. F. (2016). *The technology of teaching*: BF Skinner Foundation.

Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2016). A coming crisis in teaching. *Teacher supply, demand, and shortages in the US*.

Tyson, W. (2011). Modeling engineering degree attainment using high school and college physics and calculus coursetaking and achievement. *Journal of Engineering Education, 100*(4), 760-777.

Van Overschelde, J. P. (2013). Project Lead The Way students more prepared for higher education. *American Journal of Engineering Education, 4*(1), 1.

Van Selm, M., & Jankowski, N. (2006). Conducting Online Surveys. *Quality and Quantity, 40*(3), 435-456. doi:10.1007/s11135-005-8081-8

Wei, X., Jennifer, W. Y., Shattuck, P., McCracken, M., & Blackorby, J. (2013). Science, technology, engineering, and mathematics (STEM) participation among college students with an autism spectrum disorder. *Journal of autism and developmental disorders, 43*(7), 1539-1546.

White, D. W. (2014). What is STEM education and why is it important. *Florida Association of Teacher Educators Journal, 1*(14), 1-9.

Wieman, C. E. (2014). Large-scale comparison of science teaching methods sends clear message. *Proceedings of the National Academy of Sciences, 111*(23), 8319-8320.

Wilson, Z. S., Holmes, L., Sylvain, M. R., Batiste, L., Johnson, M., McGuire, S. Y., . . . Warner, I. M. (2012). Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines. *Journal of Science Education and Technology, 21*(1), 148-156.

Wood, W. B. (2009). Innovations in teaching undergraduate biology and why we need them. *Annual Review of Cell and Developmental, 25*, 93-112.

Anne Lucietto, Ph.D. spent twenty-six years in industry in progressively more responsible roles. She moved into academia to work with students so their transition into both industrial and academic careers is smooth without a long transition period. Her research focuses on engineering technology students and their differences from students in other STEM fields. Her interests also include those that teach STEM students, and how engineering technology students learn and interact with subjects that most find challenging. Dr. Lucietto is a Fellow in the Society of Women Engineers, a Senior Member of IEEE, a member of ASME, and ASEE.

Liza Russell is a Junior pursuing a Bachelors of Science in Mechanical Engineering at Purdue University. She began working under Dr. Lucietto in the summer of 2017 as a part of Purdue's Summer Stay Scholars program and has thus far continued as an Undergraduate Researcher. In addition to her Mechanical Engineering coursework, Liza is pursuing minors in Physics and Anthropology. In time outside of class, she serves as Treasurer and Recruitment Chair of Convocations Volunteer Network, a student-led ushering club.

Emily Schott is a Junior in Aeronautical Engineering at Purdue University. She is currently researching under Dr. Lucietto as part of Purdue's 2018 Summer Stay Scholar program. Emily is also pursuing her certificate in Entrepreneurship and Innovation. She is a member of the Purdue Society of Professional Engineers Rube Goldberg Team and the American Institute of Aeronautics and Astronautics.