# The Current Status of STEM Education Research

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## Abstract

**This paper explores the current Science, Technology, Engineering and Mathematics (STEM) education research base through an analysis of articles from eight journals focused on the STEM disciplines. Analyzed are both practitioner and research publications to determine the current scope of STEM education research, where current STEM education research is conducted and who is involved in current STEM education research. Articles from eight journals were selected based on the original authors' discussion of STEM education in the articles. The findings in this article summarize the frequency of different research methods in STEM education, the outcomes of STEM education research, the participants in STEM education research, and the universities affiliated with STEM education research.**

## Introduction

Science, technology, engineering, and math (STEM) education research is a field of wide variety and unclear parameters. The disparity of what STEM education is can be seen in the many different definitions of STEM education. Sanders (2009) suggests, "STEM education includes approaches that explore teaching and learning among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (p. 21).

The United States Department of Education (2007) provides a more programmatic definition of STEM education, "Science, Technology, Engineering, and Mathematics education programs are defined as those primarily intended to provide support for, or to strengthen, science, technology, engineering, or mathematics (STEM) education at the elementary and secondary through postgraduate levels, including adult education" (p. 11).

In contrast to the previous definitions of STEM Education, Merrill (2009) suggests STEM education is,

> A standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline specific content is not divided, but addressed and treated as one dynamic, fluid study.

The previous definitions contain one similarity – the specific criteria for collaboration between Science, Technology, Engineering, and/or Math. Zollman (2012) suggests we move beyond defining STEM education and focus more on defining STEM Literacy as a dynamic process that changes over time, not as a set construct. The overall goal should be to move from *learning for STEM literacy* to the ability to *use STEM literacy for continued learning* ( pp. 18).

While the actual definition of STEM education is up for debate, there is a clear need for more research on STEM education. Briener, Johnson, Harkness, and Koehler (2012) discovered STEM faculty working in the same departments and involved in multiple projects together did not conceptualize or define STEM in common terms. They suggest that a "one size fits all" framework is not needed for all STEM education projects, but each individual STEM education research project should have a defined conceptualization of STEM education and faculty from across the nation should be aware of these different conceptions (Briener, et al., 2012). Along with conceptualization of STEM education, we must begin to look at the motivation of STEM education initiatives. Williams (2011) suggests we need to further investigate STEM education research to determine how different methods impact the classroom, not just a focus on workplace trends and "top-down," promotion of STEM initiatives.

To investigate the STEM education research base, this article looks at the current research in STEM education. Exactly what is STEM education research? What does STEM research look like? Where is STEM research conducted? This study explores these questions as it examines the current STEM education research in each of the STEM disciplines.

## Purpose of the study

The purpose of this study is to explore the research base of STEM education. This paper addresses the following questions:Is there a research base for STEM education?

1. What is the scope of research being conducted in STEM education?
2. Where is STEM research being conducted
3. Who are the participants in STEM education research?

## Methods

This study focused on the STEM education literature found in journal articles. The journals investigated were suggested by university faculty and K-12 teachers in each STEM discipline. Articles were determined to be suitable for inclusion in the study if the original authors discussed STEM education in the manuscript and connected their article content to the field of STEM education. By connecting their work to the field of STEM education, the authors were self-identifying the articles with the STEM education research base. In the eight journals analyzed in this study, there were over 1,100 articles published from January 1, 2007 to October 1, 2010. The researchers selected the 46 month date range to focus on recent additions to the STEM research base and provide a consistent time frame for each journal analyzed.

Content analysis was used to analyze the self-identified articles. According to Patton (2002), content analysis refers to "any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" (pp. 453). Content analysis was used because it allowed the researcher to discover core themes in large amounts of written data and could effectively be implemented among all of the four STEM disciplines. The researcher used qualitative research methodology to analyze articles which were of qualitative, quantitative, and/or mixed method approaches. The researcher used a deductive approach, which uses "top-down" selected categories to investigate the articles. Using this deductive approach, the core consistencies addressed in this paper include the affiliations of authors conducting research, types of research methods used, the participants involved in the research, the overall outcomes of the research, and the STEM field in which the research is primarily focused.

This paper identifies the core consistencies of STEM education literature by reviewing eight different journals across the STEM disciplines to determine the STEM related content addressed by professionals in their respective fields. Analyzed in this paper is one academic research journal and one practitioner journal from each of the STEM disciplines (Science, Technology, Engineering,

and Mathematics). Two journals from each field were selected in an effort to explore the research at the university level and the STEM related activities occurring in the K-12 classrooms. In selecting the journals, the researcher consulted with classroom teachers and professors in each respective discipline to determine a leading research journal, as well as a practitioner journal for their specific field. The practitioner journals selected were *The Science Teacher* (ST), the *Technology and Engineering Teacher* (TTET), the *Journal of STEM Education* (STEM), and the *Mathematics Teacher* (MT). The research journals selected were the *Journal of Technology Education* (JTE), the *Journal of Engineering Education* (JEE), the *Journal of Research in Science Teaching* (JRST), and the *Journal of Research for Mathematics Education* (JRME). Summaries of the scope of each journal are included in appendix A.

To identify the STEM articles in the journals, the researcher used keyword searches through a library provided journal search engine. The researcher used the keywords "STEM", "Science, Technology, Engineering, and Mathematics" and "SMET." Through analyzing the different journal contents, the researcher found 60 articles that were directly connected with STEM education. Each article was read and analyzed using the content analysis approach previously discussed. Once again, these articles had an explicit connection by the authors to the field of STEM education.

## Findings

The findings of this study provide a descriptive analysis of the current STEM education research field. These findings show there is a research base for STEM education, summarize the scope of research being conducted by STEM education scholars, who is being studied, and the institutions in which STEM research is being conducted and published. The findings section is organized by research question.

*Is there a research base for STEM education?*

The findings from this study first suggest that there is a research base for STEM education. As previously noted, there were 60 articles identified in the selected journals that directly identify themselves as STEM education articles. Also, when investigating articles, the researcher found many articles that do not identify themselves as STEM articles, but are connected to the four disciplines in STEM education. Articles which did not identify themselves as STEM articles were not included in the study.

*What is the scope of research being done related to STEM education?*

In the initial stage of content analysis, the researcher determined that the research or writing method of the article, along with the methods used to obtain, analyze and communicate the findings. Each article was placed in one of the following seven categories. The categories were identified through the analysis of the articles. 1) Activity – Any article with the primary goal of sharing a classroom activity they have used or could use in the classroom. These articles included proper instructions for teacher and students. 2) Descriptive – These articles described a program, event, or classroom approach without organized research or a deliverable activity. 3) Editorial – Any article that was an opinion piece written by an editor or member of an editorial review board. 4) Literature – These articles used a literature review as a method of research or to provide recommendations for implementation of a program based on literature. 5) Mixed Method – Each article in this category used a mixed-method research approach. 6) Qualitative – Authors used an exclusively qualitative approach to data collection and reporting in the article. 7) Quantitative – Authors use an exclusively quantitative approach to data collection and reporting in the article.

Frequency of article method in all journals

| Method | Articles |
|---|---|
| Activity | 11 |
| Descriptive | 12 |
| Editorial | 2 |
| Literature | 3 |
| Mixed Method | 11 |
| Qualitative | 11 |
| Quantitative | 10 |
| Total | 60 |

Table 1

Table 1 shows that the methods used to research and/or discuss STEM education were evenly dispersed among activity, descriptive, mixed methods, qualitative and quantitative research. Literature reviews and editorial articles were less frequent, but proportionate to the amount of space normally allotted to editorials and literature reviews in academic journals.

Once the data were sorted by the different journals, it became clear the practitioner journals in mathematics, science, and technology focused on descriptive research and activities for the classroom teachers (table 2). The Journal for Technology Education and the Journal of Engineering Education had more qualitative and mixed method approaches compared to the Journal of STEM Education and the Journal of Research in Science Teaching. The Journal of Research for Math Education had one qualitative study.

Many articles in STEM and JTE were focused on describing the processes of practicing teachers and the experiences of teachers in professional development programs. In contrast, the JRST articles were more heavily directed with larger scale, survey type studies.

Once the methods were determined, analysis focused on the different outcomes associated with the journal articles. Six different categories were used to determine the outcome of the articles. 1) Standards Development – Writing with the desired outcome to realign standards with STEM focus. 2) Engineering Education – Articles developed exclusively for engineering education. 3) Integrative STEM – Articles with an outcome explicitly focused on more than one STEM field. Authors must discuss multiple STEM disciplines. 4) Science

Frequency of article method sorted by journal

| Method | MT | JRME | ST | JRST | TTET | JTE | STEM | JEE |
|---|---|---|---|---|---|---|---|---|
| Activity | 5 | 0 | 2 | 0 | 4 | 0 | 0 | 0 |
| Descriptive | 1 | 0 | 3 | 0 | 3 | 1 | 4 | 0 |
| Editorial | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Literature | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| Mixed Method | 0 | 0 | 0 | 2 | 1 | 2 | 4 | 2 |
| Qualitative | 0 | 1 | 0 | 2 | 1 | 4 | 0 | 3 |
| Quantitative | 0 | 0 | 0 | 4 | 0 | 1 | 3 | 2 |
| Total | 6 | 1 | 10 | 8 | 10 | 10 | 11 | 9 |

Table 2

Education - Articles developed exclusively for science education. 5) Implementation – Articles encouraging the implementation of a curriculum program. 6) Technology Education - Articles developed exclusively for technology and engineering educators.

Results from the outcome analysis are shown in Table 3. A large majority of the articles were relevant to members of multiple disciplines in the STEM community by having content directly connected to at least two fields of study. All articles in this study were self identified as a "STEM" article, as previously discussed, and through analysis of the articles it is clear these articles are part of the STEM research community and are relevant to practicing teachers in STEM classrooms because of the interdisciplinary nature of the content discussed.

As an example of the outcomes identified, Winston and Zunker (2010) provide an action research project developed into an activity, published in the *Mathematics Teacher*. Winston and Zunker use mathematics, technology and science to discuss the process "sobering up." The authors create a model for mathematics and science teachers to discuss blood alcohol content and make predictions and calculations based on mathematical and scientific modeling.

From a research perspective, Rose (2007) investigated the perceptions of technological literacy and STEM among leaders from each of the four STEM disciplines. Rose's finding suggest that different areas of technological literacy are valued more by leaders in the various disciplines. This article provides a solid connection, with clear distinctions, between the disciplines, and is informative for anyone planning curriculum in the STEM domain.

Table 4 shows the outcome findings sorted by academic journal. Overwhelmingly, the articles are focused on integrative STEM Education by including descriptive analysis of integrative activities and studies. Also, as noted on Table 4, five of the articles were focused on Technology Education, although they discussed STEM extensively.

Number of outcomes for all journal articles.

| Outcome | Count |
|---|---|
| Standards Development | 1 |
| Engineering education | 3 |
| Integrative STEM | 50 |
| Science Education | 1 |
| Implementation | 1 |
| Technology Education | 5 |
| Total | 61 |

Table 3

Article outcomes sorted by journal.

| Outcome | MT | JRME | ST | JRST | TTET | JTE | STEM | JEE |
|---|---|---|---|---|---|---|---|---|
| Standards Development | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Engineering education | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| Integrative STEM | 6 | 1 | 5 | 8 | 8 | 6 | 10 | 6 |
| Science Education | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Suggested implementation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Technology Education | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 0 |
| Total | 6 | 1 | 5 | 8 | 10 | 10 | 12 | 8 |

Table 4

*Where is STEM education research being conducted?*

The third question asks where STEM education research is being conducted. This question was investigated to explore the types of institutions in which STEM education is being conducted. To answer research question three, the researcher recorded the listed institution of each of the authors for all articles analyzed. The authors were entered into the database with their institution. Table 5 shows a summary of the frequency of an institution appearing on the journal article.

*Who are the participants in STEM education research?*

Analysis of the articles was performed to determine the participants of each journal article. Some articles used traditional research methods and worked with specific populations, while other articles were focused more on classroom research. The categories for participants emerged from the analysis of the articles and each article was grouped into one specific category. Table 6 highlights the high frequency of K-12 research conducted in the articles.

The population research clearly shows a strong focus on K-12 students, but when the data is sorted by the specific journals, we see the majority of the K-12 research was conducted for articles in the practitioner journals. The K-12 practitioner articles were mostly action research activities, in which teachers tried a new method or activity in the classroom, reported

University affiliation of authors including all journals

| University | Authors |
|---|---|
| Purdue University | 7 |
| University of Pittsburgh | 6 |
| Illinois State University | 5 |
| State University of New York College at Oneonta | 5 |
| University of Akron | 5 |
| University of Oklahoma | 5 |
| Utah State University | 4 |
| University of Georgia | 4 |
| North Carolina State | 3 |
| University of Illinois | 3 |
| University of Michigan | 3 |
| University of South Carolina | 3 |
| Vanderbilt University | 3 |

Table 5

on the results and shared detailed instructions for fellow teachers to complete a similar activity. Table 7 shows the participants of each research study sorted by journal.

## Conclusions and Recommendations

As indicated in the previous analysis, STEM education research has a wide range of methods, outcomes, subjects, and faculty working to discover more about students and teachers in STEM classrooms. There is a research base, but more research is needed in both descriptive classroom applications for practicing teachers and in rigourous qualitative/quantitative research projects. Johnson and Daugherty (2008), and others prior (Zuga, 1994, Patrina, 1998), have suggested that technology education research could be improved by using more rigorous methods. Johnson and Daugherty's (2008) argument could also possibly be made about STEM education research in the past 4 years, especially in relation to the lack of large scale STEM classroom research studies being conducted in K-12 classrooms.

When looking at research from the past 4 years in STEM education, the data in this paper suggests an even balance between academic research and action research for practitioners. These findings are heavily influenced by an even selection of practitioner's journals and academic journals researched. There are practicing teachers interested in STEM education as a method of classroom instruction, which is evident by the numerous "small" research activities developed by teachers. Also, the teachers' willingness to include other subject areas in their publications through integrated activities shows a desire to work across multiple disciplines. Clearly missing are large studies analyzing student performance and engagement in K-12 classrooms using integrated STEM instructional methods.

The institution data suggests there is interest and opportunities to study STEM education at research institutions as well as more teaching focused universities. Collaboration between faculty in STEM disciplines, along with classroom teachers is evident in the participants data in the research studies, but may need to increase to gain access and perspective to the way STEM content is understood and taught in K-12 settings.

This paper examined 60 "self-identified" STEM articles out of the collection of over 1,100 articles published in the eight journals from January 2007 to October 2010. Most (if not all) of the articles published in these journals are of STEM relevance, but not STEM identified. Missing from this analysis is a discussion of all the other activities and research studies that are STEM focused, but are not explicitly connected to other fields of study.

The very nature of STEM education means researchers must be continually looking at research from outside their specific discipline (Science, Technology, Engineering, or Mathematics). There is a research base in STEM education, but there are many opportunities to look beyond identified STEM research and look into science, technology, engineering, and mathematics research, which may not be explicitly identified as STEM education research. Moving beyond the STEM education research base can provide a wealth of information for teachers in all disciplines and provide insight into faculty and teacher expertise of other STEM disciplines.

Specific to STEM education, the practitioner journals have effectively provided activities for use by classroom teachers and insight into fellow teachers' experiences. Further research is needed in all journals, but specifically the academic research journals, to determine the effectiveness of STEM education initiatives in classroom settings, including performance data for students and teacher reflections of STEM teaching and learning.

Participants in the research studies of all journals

| Participants | Frequency |
|---|---|
| Faculty | 2 |
| graduate | 11 |
| K-12 students | 23 |
| None | 11 |
| undergraduate | 12 |
| variety survey | 1 |
| Grand Total | 60 |

Table 6

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Participants of research studies sorted by journal

| Population | MT | JRME | ST | JRST | TTET | JTE | STEM | JEE |
|---|---|---|---|---|---|---|---|---|
| Faculty | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Grad. Student | 0 | 1 | 0 | 2 | 2 | 3 | 1 | 1 |
| K-12 Student | 4 | 0 | 4 | 4 | 5 | 1 | 3 | 3 |
| None | 2 | 0 | 1 | 0 | 3 | 3 | 0 | 2 |
| Undergraduate | 0 | 0 | 0 | 2 | 0 | 1 | 6 | 3 |
| Variety | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Total | 6 | 1 | 5 | 8 | 10 | 10 | 11 | 9 |

Table 7

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