The Current Status of STEM Education Research 2013–2015

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Abstract

This paper explores the current research being done in the field of Science, Technology, Engineering, and Mathematics (STEM). The present study is a follow up to the paper written by Josh Brown in 2012, which addresses the same parameters covered during the 2013-2015 time period. The eight journals included in the former study are analyzed along with two additional journals, including practitioner and research journals. The findings were that a larger number of qualifying articles were published in a shorter time period and the articles were published from a far more diverse group of academic institutions, indicating the research base for STEM education has expanded. Undergraduate and K-12 students were the most frequent participants in the articles, and the most common themes addressed were integrative STEM, program implementation, or standards development.

Introduction

In 2013, President Barack Obama gave the U.S. Education System a call to action when he said

> "One of the things that I've been focused on as President is how we create an all-hands-on-deck approach to science, technology, engineering, and math. We need to make this a priority to train an army of new teachers in these subject areas, and to make sure that all of us as a country are lifting up these subjects for the respect that they deserve" (White House, 2013).

In response, many schools have increased their efforts at increasing interest and achievement in fields of Science, Technology, Engineering, and Math (STEM). Tsupros (2009) defined STEM education as an "interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise." While this definition is commonly accepted, research in STEM education encompasses a diverse range of parameters, with some studies focusing on a single component of STEM, and others examining the comprehensive integration of all four areas. This article looks at the multiple perspectives being explored in current STEM research, such as who is doing the research, and who are the participants being studied.

In 2012, Brown published a study in which the author analyzed 61 articles about STEM education that were written between 2007 and 2010. Brown demonstrated that there was a research base for STEM education, and that there were seven distinct categories in the scope of research. In addition, the researcher found that the research was being done at a small cluster of academic institutions and that K-12 students were the most frequently studied participants. In an effort to see how these trends have changed over time, the authors of the present study sought articles from the most recently published journals and analyzed them according to the same criteria.

Purpose of the Study

The purpose of this study is to summarize the trends and innovations in STEM education research since 2012, when a similar analysis was published by Brown (2012). In order to provide a meaningful comparison, the present paper addresses the same research questions as the former study.

1. Has there been continued development within STEM education research?
2. What is the scope of the research being conducted in STEM education?
3. Where is STEM research being conducted?
4. Who are the participants in STEM research?

Methods

This study focused on articles published from January 2013 to October 2015 in journals which met the same criteria as the original study. This date range was chosen in order to capture the most recent trends in STEM education research. The researchers began with the eight journals analyzed by Brown, which were selected on the basis of feedback from K-12 teachers and university faculty. Within the chosen journals, Brown used content analysis to identify articles which related to STEM education research and a deductive approach to classify the articles into preselected categories. In the present study, the researchers conducted a targeted search of library databases for each of the eight journals in the original study and selected articles for inclusion if they addressed STEM in the title or author supplied keywords. Articles that described a classroom activity but did not include an analysis of outcomes were excluded from the study. Some of the journals that were included in the first study did not publish articles that met the study criteria for the time period being investigated and two additional journals were added. The final list of journals included in the study were the Journal of STEM Education (STEM), the Journal of Technology Education (JTE), School Science and Mathematics (SSM), Journal of Engineering Education (JEE), the Journal for Research in Science Teaching (JRST), Technology and Engineering Teacher (TET), and the Journal of Research in STEM Education (JSTEM).

Replicating the same methodology utilized in the earlier study, the researchers conducted content analysis to categorize each article in terms of article method/research design, research focus/outcome, the university affiliation of the first and second author, and the participants used in the study. The first author was the single coder for the content analysis of the articles identified by the targeted search, but the conclusions about the appropriate categories were discussed and defended with the second author.

Findings

The findings of this study provide a descriptive analysis of the nature of research currently being done in the field of STEM education. The findings demonstrate the frequency of article method/research design in the published articles, the frequency of research focus/outcome in the published articles, the frequency of each type of participant group, and the affiliation of the first and second author of the published articles.

Has there been continued development within STEM education research?

In the original study, Brown found 60 articles written in the 45-month period from January 1, 2007 through October 1, 2010 that met the criteria for inclusion. In the 33-month period from January 1, 2013 through October 1, 2015 there were 104 articles meeting the same criteria.

Frequency of Article Method Sorted by Journal

Article Method	STEM	JTE	SSM	JEE	JRST	TET	JSTEM	Total
Activity						2		2
Description					2	1	1	4
Editorial	2		8		2			12
Literature	1			2	3			6
Mixed	4	4	7		2		1	18
Quantitative	8	1	5	3			1	18
Qualitative	6	1	1	1			2	11
Total	21	6	21	6	9	3	5	71

Table 1

Of these, 33 articles were excluded because they presented a classroom activity but did not conduct any analysis of impact on outcomes. Given that a larger number of qualifying articles were published in a shorter time period, it appears that the research base for STEM education is expanding.

What is the scope of the research being conducted in STEM education?

In the previous study, Brown conducted content analysis to identify seven types of research methods in the published articles. The present study utilized the same categories in the spirit of the original definitions:

1) Activity – Any article that described a classroom activity, along with specific instructions for a teacher to follow and an analysis of the effectiveness of the lesson.
2) Descriptive – An article that described a process, event, or pedagogy without a specific activity.
3) Editorial – Articles that were based solely on the author's opinion, but that specifically discussed STEM education research.
4) Literature Review – Articles that reviewed and summarized existing literature on the topic of STEM education.
5) Mixed Method - Articles in which authors performed a research study with both quantitative and qualitative aspects.
6) Quantitative – Articles in which authors performed a research study solely by collecting and analyzing quantitative data.
7) Qualitative – Articles in which authors performed a research study solely by collecting and analyzing qualitative data.

Table 1 shows that the method used to discuss and report findings were heavily concentrated in mixed methods, quantitative research, and editorials. Descriptive articles, activities, and literature reviews were the least frequently used approaches. The articles are sorted by the journal in which they were published to demonstrate the type of research that each journal tends to publish.

In accordance with Brown's 2012 study, the articles were categorized by outcome recommended by the author. The original paper described six categories:

1) Standards development – articles written with the intent to increase STEM focus in curricula.
2) Program implementation – articles discussing the implementation of a particular program. In the present study, the researcher found that the articles on program implementation fell into two categories: discrete events and ongoing processes. The findings are presented as two subcategories to further explain the data while preserving the original structure of the analysis.
3) Science education – articles that are exclusively relevant to the field of science education.
4) Technology education – articles that are exclusively relevant to the field of science education.
5) Engineering education – articles that are exclusively relevant to the field of science education.
6) Integrative STEM – articles that specifically discuss more than one STEM area.

Article Outcomes Sorted by Journal

Article Outcomes	STEM	JTE	SSM	JEE	JRST	TET	JSTEM	Total
Standard Development	5		9		4			18
Program Implementation								0
-Process	7	3	2		1	1	1	15
-Event	3		2				1	6
Science Education					1			1
Technology Education		1						1
Engineering Education		2	1	2				5
Math Education							1	1
Integrative STEM	6		7	4	3	2	2	24
Totals	21	6	21	6	9	3	5	71

Table 2

The authors of the present study included one additional category, mathematics education, to include articles that are exclusively relevant to the field of mathematics. Table 2 shows which type of article is most frequently published by each of the journals in the study during the research period.

Where is STEM research being conducted?

In Brown's 2012 analysis, there were 61 articles that were published out of only 13 universities. In the more recent time period, there were 71 included articles, but the first and second authors came from a much more diverse group of institutions. While Purdue remains one of the most prolific research institutions in the field of STEM, the majority of articles are coming from universities that contributed only one or two articles instead of from a handful of institutions that each produced a cluster of STEM publications. Table 3 shows the university affiliation of the first

University Affiliation of First and Second Authors

University Affiliation of Authors	STEM	JTE	SSM	JEE	JRST	TET	JSTEM	Total
Purdue University	2	1	6	2	1			12
Texas A&M University	2			3				5
Western Michigan University				2	2			4
Virginia Tech		1		2		1		4
University of Wisconsin	2			1				3
George Mason University			3					3
Washington State University			1		1			2
Utah State University	1	1						2
University of Pittsburgh	1			1				2
University of Nevada							2	2
University of Minnesota			2					2
University of Colorado					2			2
University of Arkansas	1		1					2
Stanford University					1		1	2
Old Dominion University		1				1		2
Bowling Green University			2					2
Ball State University		1	1					2
Arizona State University				2				2
Adrian College			2					2
Total*	21	9	24	13	14	3	6	90

*Total includes single publication institutions

Table 3

and second author of each article, for the institutions that published two or more articles. In addition, the following academic institutions each published a single article: Western Kentucky University, Wayne State University, Virginia Commonwealth, University of Virginia, University of Tennessee, University of Pennsylvania, University of North Carolina, University of Montreal, University of Memphis, University of Maryland, University of Kentucky, University of Helsinki, University of Dayton, University of Connecticut, University of Central Arkansas, University of Arizona, Robert Morris University, Regis University, Queensland University of Technology, Northern Kentucky, North Carolina State, Michigan State University, Massachusetts Institute of Technology, Lawrence Tech University, John Hopkins University, Jackson State University, Illinois State University, George Washington University, Florida A&M University, Eastern Michigan University, Columbia University, Colorado State University, and California State University-Los Angeles.

Who are the participants in STEM research?

The present paper analyzed the participants included in each journal article and organized them in the same categories as the original study. It is clear that the majority of research in the field of STEM education is still being conducted with K-12 students, but there has been a surge in the study of faculty since the publication of Brown's study in which only 2 of the 61 articles involved research on faculty.

Summary of Findings

As the two studies are compared, it is apparent that there are areas in which a shift has taken place. Specifically, the frequency of publication of articles regarding STEM, the number of colleges and universities participating in publishing STEM articles, the focus on participants other than K-12 students, and the number of articles featuring more rigorous research methods. Table 5 displays a comparison between the two studies.

Conclusions and Recommendations

The current analysis has demonstrated that the research base for STEM education has expanded since Brown conducted a similar analysis in 2012. This is encouraging since proficiency in STEM fields is critical to remaining a leader in the 21st century global workforce.

This paper analyzed 71 articles that focused on STEM education from seven journals published from 2013-2015. All of the articles are cited in the references section. There were varying levels of rigor and emphasis on research design in the journals chosen for the study. Articles that were editorial in nature raise awareness of STEM education issues and may provide the foundation for quantitative and qualitative research studies. A large number of articles were published in the practitioner journals that describe a classroom activity with relevance to STEM integration, but did not include an analysis of the effectiveness of the lesson. The detailed activity descriptions are helpful for teachers looking for innovative ideas to incorporate into lesson plans, but without a way to discern the impact of such interventions, the reasons for inclusion of the activities are limited.

In the original article, Brown suggested that more rigorous methods could strengthen the field of STEM education research. This remains a necessity, although since quantitative and mixed method research articles represented half of the publications in the present study, it appears that the researchers in this field have heeded this suggestion. Brown also recommended that practitioner journals publishing classroom activity articles include performance data and analyses of effectiveness, but as evidenced by the large number of such articles that were excluded from the present study, it does not appear that this has been accomplished. Suggestions for future publications are to include such outcome analyses in the papers devoted to sharing STEM educational activities. However, the abundance of available STEM classroom activities makes the possibility of conducting action research at the school level an attainable goal, which is a suggestion for future research.

Participants of Articles Sorted by Journal

Participants	STEM	JTE	SSM	JEE	JRST	TET	JSTEM	Total
Faculty	1	3	2	2			3	11
Grad Students	1			1				2
Undergraduate Students	10	1	1		3		1	16
K-12 Students	6	2	10	1	4	3	1	27
Variety	1		1	1				3
None	2		7	1	2			12
Total	21	6	21	6	9	3	5	71

Table 4

Comparison of Findings, 2012 vs. 2015

	Brown (2012)	Mizell and Brown (2015)	Change %
Number of articles published during research period	60	104	73.3
Number of publishing academic institutions	13	52	400.0
Number of articles with faculty participants	2	11	550.0
Percentage of studies using quantitative or mixed methods	35	50.7	44.9

Table 5

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