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Teaching STEM in Afterschool: Correlates of Instructional Comfort

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Abstract

Science, Technology, Engineering and Math (STEM) education is a critical component of Federal policymakers' agendas. Out-of-school time (OST) programs are designated as an important venue to teach STEM to K-12 students. Using a sample of OST direct staff in Pennsylvania (n=133), the present analysis examines instructional methods used for STEM lessons and then explores the comfort level that staff have teaching STEM. About 20% or more of staff are not comfortable teaching STEM, depending on the subject. Multivariate analyses (Mann-Whitney tests) also show that staff with fewer STEM credentials, and who work in less-networked programs, or programs with less STEM instruction overall, are more likely to express discomfort teaching STEM. Policy and planning implications are discussed.

Keywords: STEM, afterschool, instruction

Introduction

Science, Technology, Engineering and Math (STEM) education is a key component to the United States' efforts to remain a leader in innovation and a world economic frontrunner (Thomasian, 2011; Committee on STEM Education & National Science and Technology Council, 2013). Accordingly, policy makers have advocated for STEM education in Out-of-School Time programs (OST) (also known as afterschool programs) to supplement K-12 STEM efforts (Executive Office of the President, 2010; Committee on STEM Education & National Science and Technology Council, 2013). Given these recent policy directives, the importance of OST instructors' comfort teaching STEM subjects is paramount as they educate the next generation of individuals holding STEM careers.

The need for the present study is grounded in demands for informal STEM learning experiences from institutions having national and scientific import. For example, the National Academies of Sciences underscored the importance of out of school time STEM programs as an integral part of STEM learning, stating that:

> …STEM learning outside of school has become a focal piece of the education opportunities provided by many national nonprofit organizations, statewide education networks, federal programs, and corporate and family foundations. And there is growing evidence the opportunities to learn STEM outside the school directly affect what is possible inside classrooms… (Committee on Successful Out-of-School STEM Learning, 2015, p. 1).

Moreover, this study is situated in a set of pressing education policy issues revolving around STEM education generally. The research questions answered in this paper have, for instance, a direct bearing on other efforts connected to STEM in OST, such as girls' identities as scientists (Riedinger & Taylor, 2016), the persistence of American students (particularly minorities) in STEM fields (Chen, 2012; Palmer, Maramba, & Elon Dancy II, 2011) and the bearing of STEM education on the national economy (Thomasian, 2011).

It is essential to understand OST capacity as a conduit for STEM education given the prominent role that national policymakers have placed on OSTs. In particular, OST programs' capacity relies heavily on the direct service staff who teach STEM lessons. Well trained instructional staff are an essential component for OST quality and capacity, just as teacher preparation is critical for successful public schools(Darling-Hammond, 2000; Harris, 2013). For instance, in a study of "high performing" OSTs (Birmingham, Pechman, Russell, & Mielke, 2005), evaluators determined that trained staff were one of five key factors that contributed to quality OST design. These evaluators identified that "intensive in-service" training focused on curricula to be among the types of training offered by exemplary programs. Similarly, the Afterschool Alliance designated staff training as integral to quality programming (Afterschool Alliance, 2011), specifically in content areas such as STEM.

Furthermore, studies have documented the salience of emotional responses to teaching for decades (Jones & Youngs, 2012; Lortie, 1975; Veenman, 1984), thus it is not surprising that recent research shows that OST instructors' comfort with teaching STEM persists as a salient issue, particularly as comfort relates to important student outcomes. Across the research literature, investigators have utilized a number of constructs that refer to teachers' emotional responses, including anxiety (Beilock, Gunderson, Ramirez, & Levine, 2010), confidence (Avard, 2010; Howitt, 2006) and comfort (Bergman, 2015). In particular, Bergman (2015) has argued that comfort teaching science is a "central issue in science education," and has called attention to the correlation between comfort and instructional quality (Bergman & Morphew, 2015). Additionally, another study found that lower teacher comfort with STEM curricula is associated with lower student achievement and superficial treatment of STEM curricula (Beilock, Gunderson, Ramirez, & Levine, 2010).Researchers examining mathematics anxiety (a “state of discomfort”, p. 306) found that when elementary teachers were more comfortable with math subject matter, their self-efficacy teaching math was significantly higher (Swars, Daane, & Giesen, 2006). Less recently, Ramey-Gassert and colleagues (Ramey-Gassert, Shroyer, & Staver, 1996) found that teachers’ comfort with science was associated with “greater academic focus and orientation toward the science learning task at hand” (p. 305). Given the variety of constructs related to teachers’ emotional responses to STEM in earlier literature, this study sought to use a generic construct – instructional comfort – to explore the relationships it has to individual and organizational characteristics that bear on afterschool program success. The salience of comfort teaching STEM subjects is made all the more consequential based on studies that document the connection between engagement in afterschool programs and students’ school outcomes. In research on elementary students, Grogan and colleagues (Grogan, Henrich, & Malikina, 2014) found that teachers observed more academic skills in students who had more engagement in afterschool programs. Sherman and Catapano (2011) echoed these findings as they described that afterschool program participation correlated with increased mathematics achievement following participation in OST. Both of these studies link OST efforts to curriculum and instruction occurring in regular school classrooms.

Instructional comfort is a positive affective disposition toward the diverse set of decisions instructors use to create and execute STEM lessons. Instructional comfort encompasses instructors' temperament about choosing instructional materials, selecting instructional methods and activities, and executing lessons in an afterschool environment.

Nadelson, Callahan, Pyke, Kay, Dance and Pfesiter (2013) have completed some of the most recent research that specifically examines teachers' comfort teaching STEM. Using a sample of 68 elementary teachers in the western United States, these researchers surveyed respondents at two points (before and after a 3-day STEM training program) and found correlations between instructors' comfort, confidence, efficacy and knowledge about STEM subjects. Additionally, the authors found that teachers' efficacy, confidence and attitudes about engineering increased over time. The authors proposed that future research should compare differences in these outcomes by teachers' demographic characteristics.

The purpose of this study is to analyze OST instructors' instructional comfort with STEM curricula in terms of instructors' individual characteristics and OST organizational capacity. Little research on instructional comfort with STEM instruction has been conducted among OSTs, and no studies were evident that disaggregated the relationship between comfort and individual or organizational characteristics. Like Nadelson et al. (2013), the present study is an examination of comfort with STEM subject matter among a sample of instructors from OST programs. Furthermore, the analysis is expanded by considering the individual and organizational correlates of reported comfort. These conditions, which have been central to sociological perspectives in educational research for some time (see, for instance, Newmann, Rutter, & Smith, 1989), must be understood if policymakers plan to shape afterschool programs effectively. Program administrators, for instance, can utilize research on these individual and organizational characteristics to identify circumstances where more professional development may be needed. Similarly, policy makers can apply findings to design OST programs that are well designed for successful STEM curricula implementation. The study includes an analysis of three conditions that previous research suggests are important characteristics associated with comfort teaching STEM subjects. Specifically, the present study examines the relationship between comfort teaching STEM and instructors' prior knowledge, the emphasis programs place on STEM and the nature of program networking with STEM-rich institutions.

Earlier Research on Instructional Comfort and its Correlates

Investigators have examined professional comfort in diverse fields such as teaching (Wesley, Buysse, & Skinner, 2001), nursing (Corcoran, 2016) and business (Graham, Harvey, & Puri, 2015). These studies consider comfort generally, but share a common idea that emotional responses to working conditions are important mediators of performance. The present study, like those before it, is concerned with instructional comfort generally (defined above).

STEM Knowledge. The importance of subject area knowledge to academic instruction is a core area of teacher education (Darling-Hammond, 2006; Sadler, Sonnert, Coyle, Cook-Smith, & Miller, 2013) (. Subject area knowledge builds confidence in teachers, making them more apt to have positive instructional outcomes ((Darling-Hammond & Bransford, 2007), cited in Nadelson, et al., 2013). Other recent research (Nadelson, et al., 2013) has documented the positive correlation between comfort and knowledge. The National Council of Teachers of Mathematics (NCTM) stated this plainly concerning math, "Candidates' comfort with, and confidence in, their knowledge of mathematics affects what they teach and how they teach it" (NCTM, cited in Cardetti (2014), p2). For these reasons, the association between OST instructors having a STEM-related degree and comfort teaching STEM subjects is a key concern. Having a college degree is expected to be associated with greater comfort teaching STEM subjects.

STEM Emphasis in Curricula. OST programs have varying goals and program designs (Thiry, Laursen, & Archie, 2012). A defining feature of OST programs is the frequency that the programs provide instruction in different curricula (Laursen et al., 2013). When these curricula are frequently utilized, instructors have more exposure to their content, related resources and other elements embedded in curricula. Thus, when teachers or instructors work in an organizational context with a stronger curricular emphasis on STEM, they have more opportunities to acclimate themselves to STEM content and apply it in their lessons. Researchers substantiated this relationship when they used data from math teachers (Hill & Charalambous, 2012) to show that "supportive" curricula can yield higher quality instruction, by permitting instructors to use rich material, and create greater meaning in lessons. It is expected that when OSTs have more STEM curriculum in place and use it frequently, OST instructors will have greater opportunities to build comfort with their instruction.

STEM Networking Activity. Professional communities of teachers are well-established mechanisms for professional development(McLaughlin, 2010). In the OST context, professional communities may take the form of networking with partners holding extensive knowledge of STEM content, in particular for staff with less STEM content experience. Partners such as museums and universities that have highly trained scientists, for example, can offer a wealth of support and knowledge to OST programs. The Afterschool Alliance concluded that such partners, "Provide a rich source of knowledgeable and enthusiastic mentors to excite interest and provide guidance for the youth participants about STEM fields and possible career paths"(Afterschool Alliance, 2013, p. 12). Thus, this analysis of OST instructors' comfort teaching STEM subjects will account for whether their OST program has more network connections with universities. More STEM networking activity is suspected to have a positive association with greater comfort teaching STEM subjects.

Detailed analysis of how these three individual and organizational conditions relate to comfort teaching STEM will inform OST and STEM education stakeholders about the capacity of afterschool programs to implement STEM lessons.

Research Questions

The present study, in light of previous research and the purposes stated above, will address the following research questions:

1. What types of instructional activities are utilized among OSTs to teach STEM subjects?
2. What amount of program time do OSTs allocate to STEM instruction?
3. What is the magnitude of instructional comfort for different How comfortable is OST instructional staff in teaching STEM subjects?
4. How are levels of instructional comfort related to STEM Knowledge, STEM Emphasis in curricula, and STEM Networking?

This study is important because little is known about the inter-workings of OST staff outputs and individual/organizational characteristics. Furthermore, this study presents a unique exploration of the instructional experiences of direct service staff. In the remainder of this article, the methods for collecting and analyzing survey data are presented, followed by a presentation of the results. Finally, a discussion of study implications is presented.

Methods

Research Design

The present study is based on a convenience/snowball sample that was collected with a cross-sectional online survey of OST programs across Pennsylvania. Eligible respondents, who were permitted to submit data anonymously, were instructional staff from various Pennsylvania OST program, regardless of their affiliation or programmatic emphasis. Follow-up phone calls and emails were used to enhance response rates (Dillman, 2000). Data collection occurred in Spring 2014.

Instrument

This study presents data gathered through a statewide survey that was designed to investigate the frequency of STEM instructional activities and training in OST and compare levels of STEM activity by OST characteristics. The survey measured characteristics of OST programs, including location, enrollment, hours of operation and their various resources. Stakeholders of OST in Pennsylvania used this survey because it offered a broad perspective on afterschool program structure and activities across the Commonwealth of Pennsylvania. Additionally, the survey included items about STEM instruction that were related to program funders' goals for OST growth in Pennsylvania. More specifically, stakeholders and funders were (and remain) concerned about the status of STEM education in Pennsylvania OST and whether OST have sufficient capacity to provide STEM education adequately.

The survey instrument included items that measured the STEM educational backgrounds of respondents (STEM Knowledge), the amount of STEM instructional programming at their site (STEM Emphasis), and the frequency of STEM-related networking (STEM Networking). Table 1 presents more detail on these items (see rows 4, 5, 6 respectively). Specific to this study, the survey included an item measuring the self-reported “comfort” that instructional staff have in teaching four STEM areas (science, technology, engineering and math). The instructional comfort survey item used a four-point Likert scale (i.e. agreement) to measure comfort for each of the four STEM areas (“How comfortable are you in implementing [SCIENCE / TECHNOLOGY / ENGINEERING / MATH] content and activities in your OST program?”; see Table 1, row 3).

The survey was utilized first in Spring 2012 to gather pilot data, and these pilot data were examined to improve question design for the 2013 survey. Experts in the OST/STEM field provided a detailed review of the survey prior to the 2013 administration to insure it used questions that were relevant to respondents and stakeholders who would utilize the data for program capacity building. Reviewers included academic researchers who specialized in analysis of OST programs, professional OST advocates, and OST program administrators. These reviewers utilized pilot test data to identify items lacking face validity and ensure that items represented the full domain of issues pertaining to afterschool programs.

Respondents

This study focuses on 133 OST instructional staff who responded to the survey. The respondents worked in 28 Pennsylvania counties, with 42% of responses from Philadelphia and Allegheny counties. OST enrollment in these respondents’ programs varied; Table 2 shows that about one-fifth had fewer than 30 students, 23% had between 31-50 students, and about one quarter had 51-100 students. The remainder of programs (about 31%) served more than 100 students. By grade level, K-5 (76% of respondents) and 6th – 8th graders (29% of respondents) were the most common age groups served by OST programs. About 67% of all respondents had a bachelor’s degree or higher although only about 16% of respondents had a STEM-related degree. The majority of respondents work in OSTs that are situated in school-buildings (65%), while others worked at OSTs in community/recreation centers (15%), or religious institutions (11%). Overall, the respondents worked at a diverse group of OSTs, increasing the sample's reliability (Henry, 1990). Detailed response rates are not possible to calculate because the total number of afterschool programs in Pennsylvania is not known; nonetheless the geographic diversity of the sample lends to its external generalizability.

Measures

The present study uses several measures. Each is described in turn.

STEM Activities. To determine the types of instructional activities that are utilized by OST staff to teach STEM subjects, this research used measures that examined both STEM instructional activities and activities in other subjects that integrated STEM content. Two survey questions ("What types of STEM activities are offered in your STEM programs?" and "Which of the following subjects are integrated with your STEM activities?") offered "check all that apply" options to respondents because programs typically utilize a variety of activities and subjects simultaneously as determined in previous surveys (Cohen, n.d.) of Pennsylvania OST. Distributions on these questions are shown in the Results section.

Comfort Teaching STEM. Using a survey item measuring comfort teaching STEM subjects (Table 1, row 3), the four response options were collapsed into two: "Less Comfort" defined as being "not at all" or "slightly" comfortable, and "More Comfort" defined as being "somewhat" or "very" comfortable. Distributions are shown in Table 3 (rightmost "total" column).

To assess the reliability of the instructional comfort measure a split-half reliability coefficient and a Cronbach alpha were computed using STATA/IC v12.0. The split-half reliability coefficient, using Spearman-Brown's prophecy formula (DeVellis, 2011), was 0.85, while internal reliability of the four items was 0.81. Higher reliability coefficient values are necessarily constrained in this analysis because the comfort scale consists of only four items (each STEM area) and the measurement scale was designed with four points to minimize burden on respondents (Strongly Agree to Strongly Disagree). These coefficient values suggest a consistent measurement of an underlying instructional comfort construct.[1]

STEM Knowledge. Respondents who indicated having a degree in a STEM-related field were defined as having "more" STEM Knowledge while those without a degree were defined as having "less."

STEM Emphasis. Respondents whose OST programs indicated dedicated 50% of program time to at least one STEM subject area were defined as having "more" STEM Emphasis while those dedicating less time were defined as having "less".

STEM Networking. Respondents whose OST programs had "always" or "often" established partnerships with at least one other institution to enhance STEM were defined as having "more" STEM Networking while those without these partnerships were defined as having "less."

[1] Indeed, Nadelson and colleagues (2013) found a correlation between a similar Likert-type measure of comfort and "efficacy for teaching" (p. 162).

Analysis Methods

The analytic approach was exploratory due to the dearth of previous studies that examined the relationship between comfort teaching STEM subjects and OST characteristics. In order to determine how staff comfort in teaching STEM related to STEM Knowledge, STEM Emphasis and STEM Networking, I compared the percentage of respondents having low or more comfort levels by STEM training, STEM program emphasis and STEM partnerships. To account for the categorical and ordinal nature of the data, Mann-Whitney tests of group differences were computed (Leeper, 2009) for examining the distributions in the resulting 2x4 cross tabulations with SPSS ver 18.0 (SPSS Inc., 2009). The data used for this analysis meet the assumptions of the Matt-Whitney test, as summarized by Conover (1999). Specifically, the Mann-Whitney test assumes that the two samples (defined by the dichotomous independent variables described in the Measures section above) of the instructional comfort variable are random, that mutual independence exists between the two samples and the outcome variable is measured on an ordinal scale (Conover, 1999). While the sample used for this analysis is not randomly selected, a diverse set of OSTs is represented in the sample, in turn reducing the potential bias that might result from one particular type of OST being oversampled. The Discussion (below) provides an explanation of how results of this analysis should be interpreted given this limitation. To the extent that the distributions compared have too many ties (i.e. are not mutually independent), a statistical adjustment for ties was computed with STATA's ranksum command (StataCorp., 2011). The outcome data used in these analyses are ordinal, and thus meet the assumptions stated above.

Results are reported using a graphical presentation that shows the percentage of respondents who report high or low comfort for each of the independent variables (STEM Knowledge, STEM Emphasis and STEM Networking). The intent of the analysis is to describe *relationships* between comfort teaching STEM among staff in OSTs and staff/organizational characteristics. Given the sampling methods used for the survey, the analysis is not meant to be a definitive estimate of Pennsylvania's OST program population, however, it begins to uncover important patterns related to teaching STEM in OSTs.

RESULTS

Frequency and Type of STEM Instruction

To engage students, teachers generally employ a variety of instructional techniques. Similarly, OST staff utilized a range of instructional activities in their efforts to engage students, most commonly hands-on activities (94 percent of respondents), small-group activities (85 percent), discussions (71 percent) and experiments (73 percent) (Figure 1). Less common were guest speakers (46 percent) and lectures (17 percent). Science fair projects were least often used (15 percent) to engage students among the activities respondents rated.

Respondents also reported that STEM instruction in OST is integrated frequently with other subjects (Figure 2). Seventy percent of survey participants responded that STEM is integrated with "Arts" subjects and 66% reported that "literacy" is integrated with STEM. Sports and recreation and civic engagement were less likely to be integrated, with fewer than half of respondents reporting integrating these subjects with STEM.

Additionally, survey respondents reported that their OST made varying allocations of time to each STEM area. In the survey, respondents could report overlapping time allocations because

STEM subject areas overlap. Math and science were the most common STEM areas to which OST instruction time was allocated. About 62% of respondents dedicated more than one-fifth of their program time to math, and 50% of respondents dedicated more than one-fifth of their program time to science. Technology and engineering were less common in OST. About 43% of respondents dedicated more than one-fifth of their program time to technology, while only 26% dedicated this amount of program time to engineering.

In short, STEM instruction in OST programs is immersed in a rich texture of different methods and combined with different subject matter. Finally, programs give a broad range of programmatic emphasis to STEM curricula, as evidenced by the time they allocate to STEM-related instruction, but this emphasis falls more on math and science than technology and engineering instruction.

Comfort Teaching STEM Subjects

Respondents reported how comfortable they are teaching each of four STEM areas (science, technology, engineering and math). Many OST staff generally were comfortable implementing STEM curricula. For instance, respondents reported that science and math were subjects they are most comfortable teaching, with 47% and 49% indicating they are "very comfortable" with these subjects, respectively (Table 3, rightmost "total" column). However, important proportions of staff indicated they were much less comfortable teaching engineering topics. For instance, 48% of all respondents indicated they were only "Slightly" or "Not At All Comfortable" implementing engineering curricula. Additionally, 19, 25 and 20% of respondents reported they were "Not At All Comfortable" or only "Slightly Comfortable" in science, technology, and math, respectively. Table 3 presents these data in detail (rightmost "total" column).

How "Comfort" Varies

Characteristics of the OST instructors and their organizations help to explain how instructors' comfort level teaching STEM subjects varied. This analysis examined whether having a STEM-related Bachelor's or higher degree, an emphasis on STEM curricula, and OST networking capacity was related to comfort (defined as being "somewhat" or "very" comfortable) teaching STEM subjects. The results of these analyses are shown in Figure 3, in which each set of bars exhibits a different individual or organizational characteristic correlated with staff comfort implementing STEM curricula.

STEM Knowledge. The first and second set of bars shows that greater levels of comfort teaching STEM subjects was evident among respondents holding a STEM degree compared to those who did not. For example, Figure 3 shows that when staff had more STEM Knowledge they were more likely to be comfortable teaching science (95 versus 79%, $U=733.5$, $p<.01$), engineering (62 versus 50%, $U=840.0$, $p<.05$) and math (90 versus 79%, $U=787.5$, $p<.01$). Differences for technology were not statistically significant.

STEM Emphasis. Characteristics of OSTs also related to staff comfort implementing STEM. Specifically, greater levels of staff comfort were associated with the frequency that STEM curricula were implemented in an OST. For instance, the third and fourth set of bars in Figure 3 show that when OST sites reported that they dedicated more than 50% of their programmatic time to at least two STEM areas ("More" in Figure 3), staff were more likely to report being comfortable implementing STEM curricula than those in the "One or Fewer" category. Among staff in sites with more STEM programming, 96% of respondents were more comfortable implementing science while only 78% of respondents were as comfortable in OSTs implementing STEM less often ($U=1035.5$, $p <.05$). A similar pattern exists with technology

(U=925.5, p<.01), while for engineering about 80% were more if their OSTs implemented STEM frequently while only 45% were as comfortable in OSTs implementing STEM less often (U=808.5, , p<.01). Differences for implementing math curricula were not statistically significant (Mann-Whitney U=1135.0, p>0.05).

Networking. Another organizational characteristic correlated with staff comfort implementing STEM is the frequency that OSTs form networks with different organizations (fifth and sixth set of bars in Figure 3). Greater levels of comfort implementing STEM were associated with more frequent networking with external organizations (such as with museums, businesses, environmental centers and higher education). For instance, 92% of respondents working with more networked OSTs were more comfortable teaching science while 77% of respondents felt this way in less networked environments (U=1269.0, p<.01). About 92% of respondents were similarly comfortable teaching technology in more networked organizations, while 69% were comfortable in less networked organizations (U=1252.0, p<.01). About 67% of respondents in more networked OSTs were comfortable teaching engineering while only 46% in less networked OSTs were (U=1301.0, p<.05). Differences for math were not statistically significant.

Greater differences in STEM comfort were associated with STEM Emphasis and STEM Networking compared to the differences associated with STEM Knowledge. Among those statistically significant differences, the average difference for STEM Emphasis was 26 percentage points, and 19 percentage points for STEM Networking. The average difference for STEM Knowledge was 14 points.

Discussion

An important proportion of instructional staff in OST programs experiences discomfort teaching STEM subjects. Indeed, about one-fifth or more of these instructional staff indicate they are "not at all" or only "slightly" comfortable teaching one or more STEM subjects. Such a proportion translates to a large number of school-aged children who are relying on these uncomfortable OST STEM instructors.

Individual and organizational characteristics were important correlates of the comfort instructors felt teaching STEM subjects. Differences in the comfort levels were more substantial for the two organizational characteristics (STEM Emphasis and STEM Networking) measured in this study, than the individual characteristic analyzed herein (STEM Knowledge). The present study indicates that children in programs with smaller STEM Networks or without a programmatic STEM Emphasis are more likely to experience STEM lessons from instructors who are less comfortable delivering these lessons. Even more, the data show that children whose instructors have less STEM Knowledge are likely to have lessons in science, engineering and math that are taught from uncomfortable instructors.

Implications for STEM in OST

The results substantiate that organizational qualities are an important element in creating more effective STEM programs in afterschool settings. In fact, STEM Emphasis and STEM Networking mirror concepts in the organizational theory literature, which emphasize "core competencies" and "collective learning" among other variables that are necessary to sustain effective organizational learning (Nevis, DiBella and Gould, 2009). The limited resources available to OST programs may make the application of organizational learning particularly salient if the current press for STEM remains in place. When OSTs are strapped with little funding, their ability to promote strong networks is all the more important to successful STEM instruction. To the extent that OSTs do not improve staff comfort teaching STEM subjects may impact the 10.2 million children currently enrolled in afterschool programs (Afterschool Alliance, 2014) – the impact OST instructional staff can have on STEM education is potentially very large when viewed on the national scale.

National STEM education goals seek to grow the number of high quality scientists, and science literacy generally, in the United States. OST programs have been cited as one way to increase "child and youth literacy and engagement in science"(Hussar, Schwartz, Boiselle, & Noam, 2008, p.3). To win children's engagement and achievement in science, OST staff must have sufficient STEM knowledge and inquiry techniques, as well as the comfort to apply that knowledge (Czerniak & Chiarelott, 1990). The findings presented above highlight that an important proportion of OST instructors are not comfortable teaching STEM, particularly engineering. Furthermore, lower levels of STEM Knowledge, STEM Emphasis and STEM Networking appear to have a role in sustaining discomfort.

To build staff comfort in teaching STEM curricula, OST programs can take at least two key actions. First, OST programs can designate specific training necessary for implementing STEM curricula based on program quality standards (Westmoreland & Little, 2005). Such standards will provide OST administrators with guidance on how to recruit and train OST staff. Professional development that imparts STEM knowledge and related pedagogy is a prudent investment for OST staff (Bowie & Bronte-Tinkew, 2006) given that one-fifth or more of respondents in this study were uncomfortable teaching STEM subjects. Indeed, 65% of survey respondents indicated in other survey items that "more time to study STEM" and "time to attend

STEM workshops" would be "very" or "highly" likely to impact STEM implementation at their OST.

Second, OST programs can increase their networks with universities, museums and science centers to mentor OST staff about STEM. University networking may also complement any efforts OST programs take to define quality standards, because higher education faculty can assist OST staff with STEM assessment indicators and content. Future research should examine the results of these recommendations with larger and more representative samples.

Limitations

This study uses a small convenience sample which may impact external validity, however, the respondents to the survey represent dozens of OST programs from a wide geographic swath of Pennsylvania, including inner city neighborhoods as well as rural areas in the northwest and southern borders of the state. This study would benefit from a larger randomized sample of OST instructors to increase the likelihood of representative results, however, no definitive list of OSTs exists to allow scientific sampling. Despite these limitations this analysis has the key advantage of utilizing a sample that permits a novel examination of both STEM teaching comfort and its individual and organizational correlates. In doing so it informs stakeholders about important dynamics related to STEM instruction.

Future studies can employ more rigorous measures of STEM teaching efficacy to increase internal validity. Future research might also use multivariate analysis to examine whether one of the individual or organizational characteristics might have a greater role than another. Such research might also utilize multilevel models to account for the nested nature of organizational data as well.

Finally, it is useful to consider why certain STEM subjects did not always differ for each individual or organizational characteristic. For instance, comfort teaching math did not vary by whether OSTs had more or fewer network connections, while other STEM areas did. Future research could explore if the invariance is due to sample characteristics, wherein respondents had access to partnerships of differential capacity in math curricula.

Conclusion

Expanding partnerships between OSTs and STEM-rich institutions, growing a rigorous STEM curriculum and identifying staff with stronger STEM backgrounds can enable OSTs to enhance STEM instruction. Highly qualified staff are increasingly important as OSTs confront challenges of limited resources and meeting myriad goals that compete with STEM instruction. If OST programs are to play a role in growing more STEM college graduates, additional professional development, technical assistance and expanded networks are likely to be necessary.

Figure 1: Percentage of Respondents Who Reported Activities Utilized in STEM Instruction

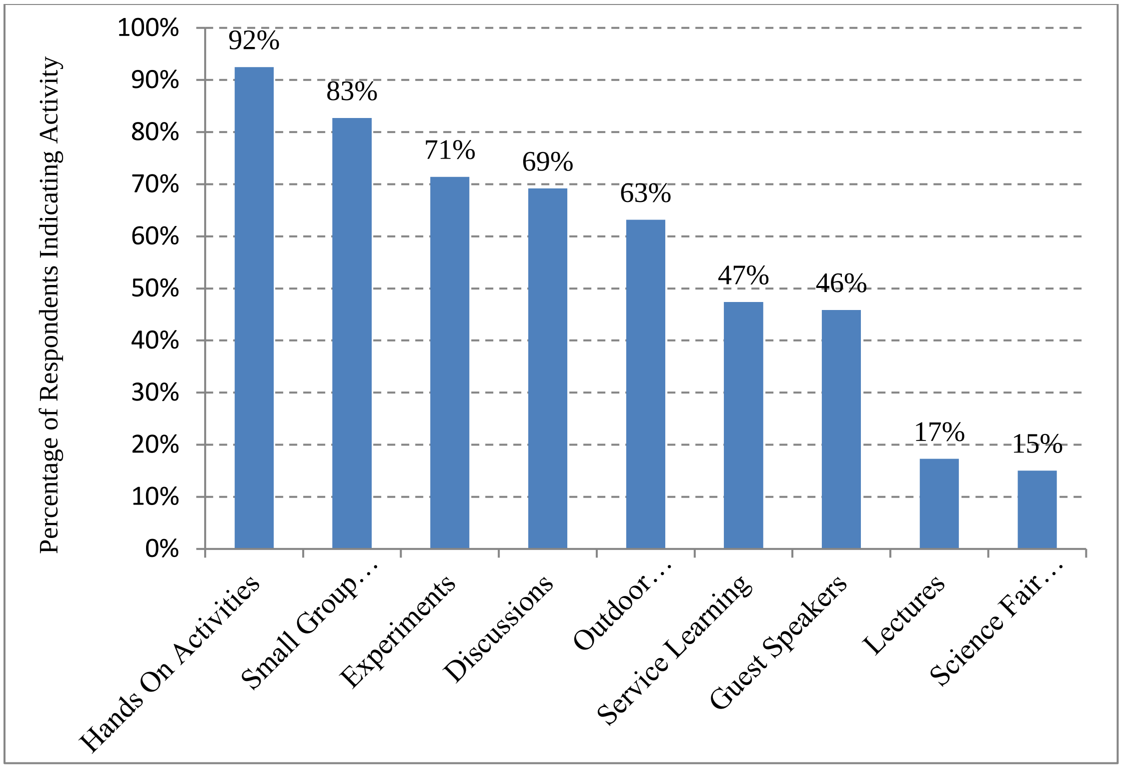

Figure 2: Percentage of Respondents Who Reported Other Subjects Integrated with STEM

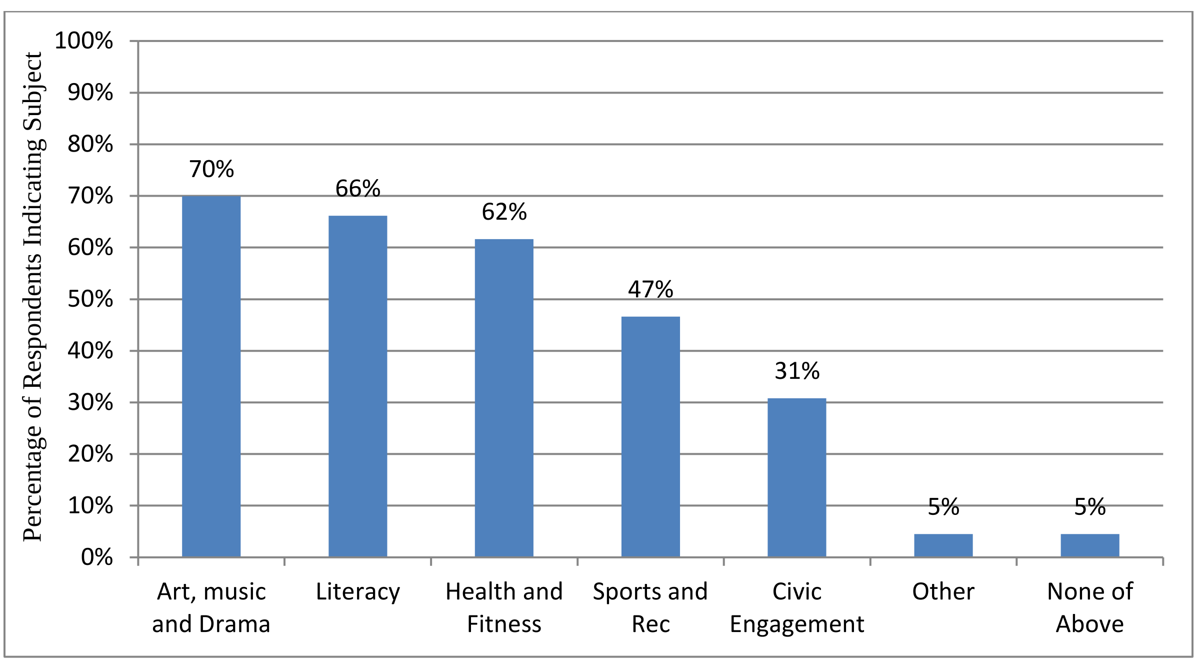

Figure 3: Percentage of Direct Service Staff Who Are "Somewhat" or "Very" Comfortable

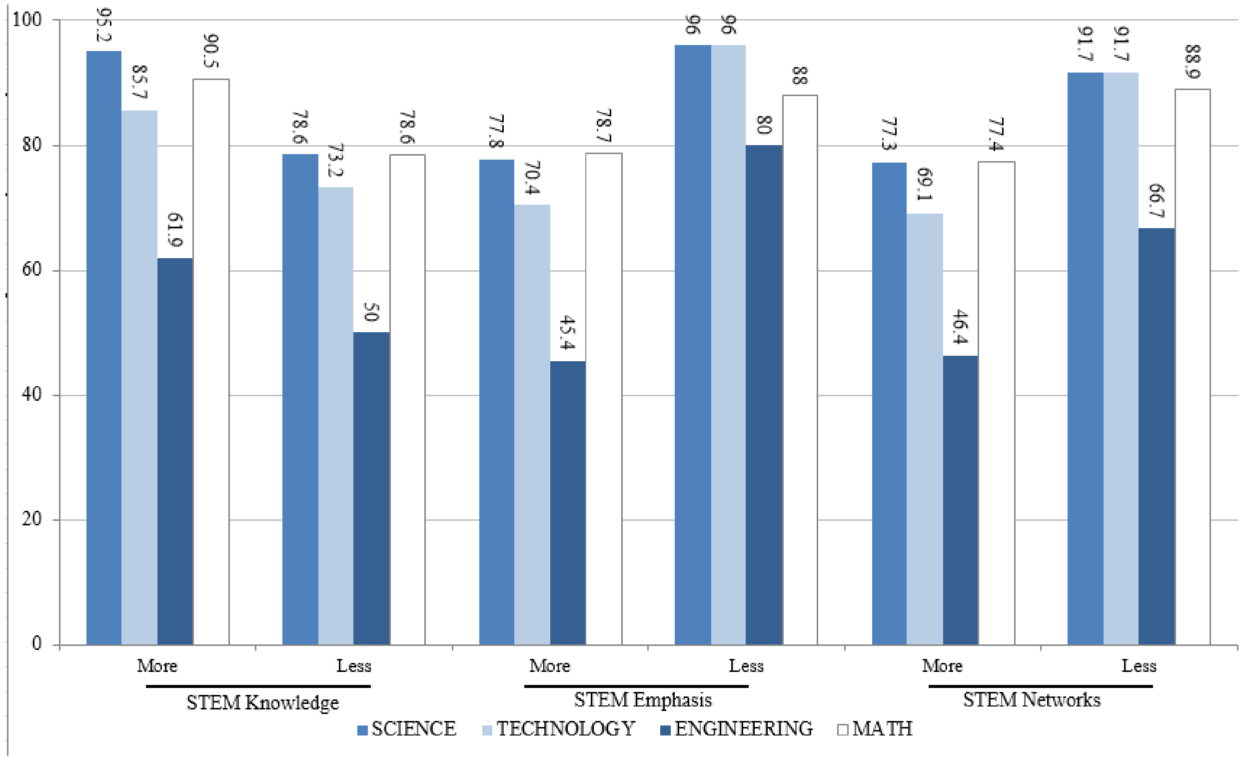

Table 1: Key Survey Items and Measures

Row	Original Question and Response Options
1	**What types of STEM activities are offered in your OST program?** *Check all that apply.* [14 response options such as "experiments", "lectures", etc..]
2	**Which of the following subjects are integrated with your STEM activities?** *Check all that apply.* [Art/civic engagement/Health/Literacy/Projects/Sports]
3	**How comfortable are you in implementing [science/technology/ engineering/math] curricula in your program?** [Not at all comfortable/Slightly/Somewhat/Very comfortable]
4	**Approximately what percentage of your program hours are devoted to [science/technology/ engineering/math]? [STEM Emphasis]** [None/1-20% of program hours/21-50%/51-75%/76-100%]
5	**Do you have one or more postsecondary degrees in either Science, Technology, Engineering, or Math? [**STEM Knowledge] [Yes/No]
6	**How often does your program partner with [museums, environmental centers, colleges, businesses] to enhance STEM? [**STEM Networking] [Always/Often/Sometimes/Seldom/Never]

Source: Center for Schools and Communities Statewide STEM Survey © 2013

Table 2: Characteristics of the Sample

Respondents by Highest Degree	n	% of Cases
High school diploma	18	13.50%
Associates degree	22	16.50%
Bachelor’s degree	44	33.10%
Master’s degree or equivalent	44	33.10%
Doctoral degree	1	0.80%
Other	4	3.00%
Respondents by Size of Program		
None	1	0.80%
1 to 30	28	21.10%
31-50	31	23.30%
51-100	32	24.10%
101 or more	41	30.90%
Respondents by Location of Program*		
School Building	86	64.70%
Community Center	14	10.50%
Recreation Center	6	4.50%
Faith-based Organization	14	10.50%
University	1	0.80%
Cultural Institution	4	3.00%
Business	11	8.30%
Other	24	18.00%
Respondents by Grades Served by Program*		
K-5th Graders	101	75.90%
6th - 8th Graders	67	50.40%
9th - 12th Graders	18	13.50%
Special Needs Youth	24	18.00%
ESL Youth	17	12.80%
School Drop Outs	3	2.30%
Other	2	1.50%

Note. * Multiple response item.

Source: Center for Schools and Communities Statewide STEM Survey © 2013

Table 3: Comfort Teaching STEM by Individual and Organizational Characteristics

		STEM KNOWLEDGE		STEM EMPHASIS		STEM NETWORKS		
		Less N=112	More n=21	Less n=108	More n=25	Less n=97	More n=36	**TOTAL**
		N %	N %	N %	N %	N %	N %	N %
SCIENCE	Not at all comfortable	5(4.5)	0(0)	5 (4.6)	0 (.0)	5 (5.2)	0 (.0)	5 (3.8)
	Slightly comfortable	19(17)	1(4.8)	19 (17.6)	1 (4.0)	17 (17.5)	3 (8.3)	20 (15.0)
	Somewhat comfortable	42(37.5)	4(19)	37 (34.3)	9 (36.0)	36 (37.1)	10 (27.8)	46 (34.6)
	Very comfortable	46(41.1)	16(76.2)	47 (43.5)	15 (60.0)	39 (40.2)	23 (63.9)	62 (46.6)
TECHNOLOGY	Not at all comfortable	5(4.5)	0(0)	5 (4.6)	0 (.0)	5 (5.2)	0 (.0)	5 (3.8)
	Slightly comfortable	25(22.3)	3(14.3)	27 (25.0)	1 (4.0)	25 (25.8)	3 (8.3)	28 (21.1)
	Somewhat comfortable	42(37.5)	6(28.6)	38 (35.2)	10 (40.0)	34 (35.1)	14 (38.9)	48 (36.1)
	Very comfortable	40(35.7)	12(57.1)	38 (35.2)	14 (56.0)	33 (34.0)	19 (52.8)	52 (39.1)
ENGINEERING	Not at all comfortable	26(23.2)	1(4.8)	25 (23.1)	2 (8.0)	23 (23.7)	4 (11.1)	27 (20.3)
	Slightly comfortable	30(26.8)	7(33.3)	34 (31.5)	3 (12.0)	29 (29.9)	8 (22.2)	37 (27.8)
	Somewhat comfortable	40(35.7)	5(23.8)	34 (31.5)	11 (44.0)	31 (32.0)	14 (38.9)	45 (33.8)
	Very comfortable	16(14.3)	8(38.1)	15 (13.9)	9 (36.0)	14 (14.4)	10 (27.8)	24 (18.0)
MATH	Not at all comfortable	10(8.9)	0(0)	9 (8.3)	1 (4.0)	8 (8.2)	2 (5.6)	10 (7.5)
	Slightly comfortable	14(12.5)	2(9.5)	14 (13.0)	2 (8.0)	14 (14.4)	2 (5.6)	16 (12.0)
	Somewhat comfortable	39(34.8)	3(14.3)	35 (32.4)	7 (28.0)	31 (32.0)	11 (30.6)	42 (31.6)
	Very comfortable	49(43.8)	16(76.2)	50 (46.3)	15 (60.0)	44 (45.4)	21 (58.3)	65 (48.9)

Note. Shaded cells indicate no statistically significant difference between the "less" and "more" columns for each STEM area, at p < .05 or better using a Mann-Whitney U test.

Source: Center for Schools and Communities Statewide STEM Survey © 2013

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