

## RESEARCH REPORT

# A Summer Stem Outreach Program Run By Graduate Students: Successes, Challenges, And Recommendations For Implementation

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**Abstract:** Providing science, technology, engineering and mathematics (STEM) experiences to middle and high school students outside of traditional classroom settings is critical in preparing learners to be literate in these fields. At the same time, providing graduate students in science and mathematics with independent pedagogical opportunities that prepare them to effectively teach and communicate STEM subjects to the general public are exceedingly rare. Here, we present the Foundations in Science and Mathematics program (FSM), a rapidly growing summer STEM educational program operated entirely by graduate students at Indiana University, Bloomington, that seeks to achieve both of these goals. First, we detail the organization and scope of FSM, the extent to which it grew since its founding in 2011, and the general aims and design of its courses. Second, we address the demographic composition of the program, and evaluate its pedagogical success through learning evaluations and student surveys that gauge student academic improvement and course satisfaction, respectively. Overall, we find that FSM significantly increased student learning and that courses were given favorable reviews by students. Finally, we discuss the logistical operation of FSM, with the goal of assisting motivated graduate students in developing similar programs at other academic institutions. In combination, we find that FSM was highly successful at achieving its goals of enhancing student learning and promoting effective pedagogy among graduate students, and we encourage other institutions to establish similar programs in their own academic communities.

**Keywords:** Secondary education, Extracurricular STEM Activities, STEM graduates

## Introduction

Though access to a high-quality science and mathematics education is widely sought after, providing students with such educational opportunities outside the classroom can be a major challenge, as many existing opportunities are cost-prohibitive or regionally unavailable (Allen & Chavkin, 2004; Cook et al., 2015). Universities can play a unique role in filling this void in their communities, as science and mathematics departments possess intellectual and material resources otherwise unavailable to local K-12 schools, and graduate students are often eager to gain experience in teaching and pedagogy (Tanner and Allen, 2006; Reeves et al., 2018). Indeed, while graduate students may serve as teaching assistants, these appointments are often limited in scope, providing few or no opportunities for independent instruction or curriculum development (Davis and Kring, 2001; Cherrstrom et al., 2017). Therefore, extant teaching opportunities often fail to sufficiently prepare graduate students to teach independently and develop effective curricula (Parker et al., 2015; Kim et al., 2017).

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Further, although graduate students increasingly participate in local outreach and “scientist in the classroom” programs, these are generally short in duration (often lasting a day or less), and present few opportunities for feedback and assessment (Laursen et al., 2007; Ufnar, 2017). This paper describes a program that attempts to address the needs of both groups to a substantial degree, providing secondary students affordable enrichment in the sciences and mathematics, while giving graduate students more substantial and autonomous opportunities for teaching and curriculum development.

The Foundations in Science and Mathematics (FSM) program is a graduate student-led summer educational program for middle and high school students now in its eighth year at Indiana University, Bloomington (IU). This program seeks to accomplish four primary objectives: i) to supplement the STEM education of local middle and high school students, in part by ii) fostering collaboration between IU and local educational institutions, while iii) providing independent teaching and curriculum development experiences to graduate students, and iv) allowing graduate students to develop program management, leadership and communication skills. The program began in 2011 with fewer than 60 high school students, and only four remedial/preparatory courses in mathematics and physics (Bennett et al., 2012; Timme et al., 2013). Since that time, FSM grew substantially; its annual enrollment and course offerings are a substantial component of IU’s pre-college outreach efforts, and it is now a well-established feature of the local educational ecosystem. In the following sections, we provide an overview of FSM, discuss its demographic composition and student-learning achievements, and share our successful strategies for maintaining and growing the program. We share this to enable others to bring FSM to their campus or to develop similar programs.

### *Program Overview*

The FSM program offers preparatory, supplementary, and exploratory courses in science and mathematics for approximately 150 area middle and high school students each year. Graduate students are responsible for the entire operation of the program, and do so at two levels including i) as instructors who teach courses commensurate with their disciplinary expertise and ii) as administrators who handle logistic and budgetary concerns. The program consists of two individual two-week sessions, one held in June and the other in July, and offers approximately a dozen distinct STEM courses in each session. Traditionally, these courses included introductory and advanced instruction in core high school biology, chemistry, physics, and mathematics (e.g. algebra, calculus, trigonometry) content, with more recent and interdisciplinary course offerings including astronomy, astrophysics, brain science, the chemistry of food, computer programming, environmental science, evolutionary biology, forensic science, and zoology – offerings that go beyond typical curricula. Each course has a limited enrollment of up to fifteen students and meets for two hours per day, three days per week during the two-week period, for a total of twelve hours of instruction time. In addition to demonstrations and lecture-based instruction, class meetings utilize active learning strategies with hands-on activities (see Appendix for an example), group work, and discussion to improve learning and engagement (Freeman et al., 2014; Schwartz et al., 2016). Each course focuses on foundational concepts and introductory materials, with a special emphasis on analytical and quantitative reasoning skills, and aims to improve students’ background and confidence with the material. At the end of each session, the program provides students the opportunity to tour IU research facilities in order to provide them with an understanding of how the concepts learned in their classes apply to contemporary research programs.

Curricula for FSM courses are conceived of and developed using a variety of different sources. Instructors preparing courses for required or core school subjects, for instance, use Indiana state standards (including ISTEP+ standardized testing requirements) and College Board Advanced Placement standards to guide curriculum development. In many cases, these standards are reviewed with local teachers who highlight topics that are of particular importance or are especially challenging for students. The framework that these standards and the teachers provide allows FSM to design preparatory courses that align closely with the curricula of students’ base schools. To familiarize students with the subject matter, courses attempt to capture as much of the breadth of their intended subject as reasonably fits in the two-week time constraint. This time

constraint is one reason why instructors have not included more inquiry-based investigations in their curricula. Further, the program also provides the opportunity for secondary students to participate in unique graduate student-designed activities such as experiments and field-based observations that leverage university resources, activities likely unavailable at their base schools.

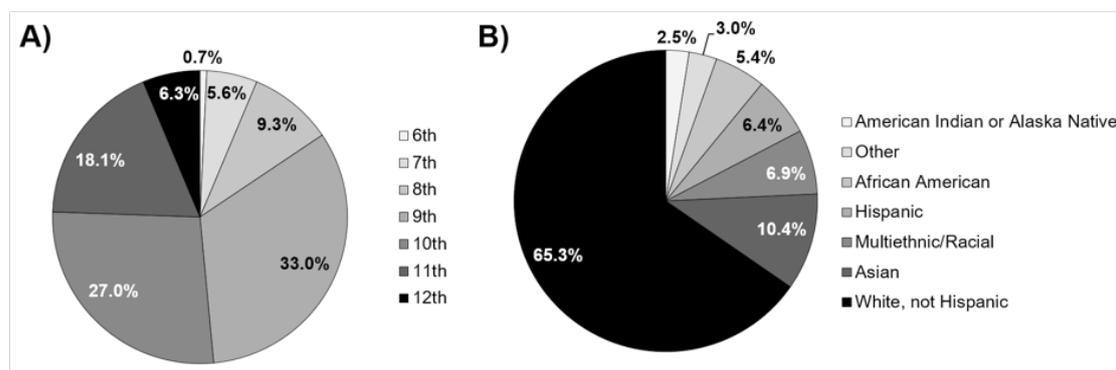
In addition to core courses, FSM offers exploratory courses designed to address particularly challenging concepts or subject matter, as well as to introduce material that enriches the material typically taught in schools. These courses are often developed using suggested material from scholarly societies. For example, the evolutionary biology course, *Our Evolving World*, was designed using i) recommended standards from two scientific societies that identified particularly challenging evolutionary concepts and ii) peer-reviewed articles that identified widely-held misconceptions about evolution (e.g. Society for the Study of Evolution; Nadelson & Southerland, 2010; Nehm et al., 2012). We took a similar approach to curriculum design for other exploratory courses, which give students the opportunity to engage in the study of topics that are interdisciplinary (e.g. brain science, forensic science) or address other special topics (e.g. astronomy, computer programming, zoology) that are typically not addressed in local schools. In many cases, material is developed de novo by those instructors with expertise in the area, adapting material from undergraduate-level introductory courses in the relevant field (see Appendix for an example from *Our Evolving World*). These supplementary courses have become extremely popular in recent years; for instance, in 2017 approximately 46% of all course registrations came in these courses. As reflected in student course evaluations (see below), this is likely because these courses give students opportunities to engage with unfamiliar topics and, in some cases, apply what they know from different subject areas in new contexts.

As STEM researchers, there has been an inherent interest in collecting evidence of impact since the start of FSM. In order to evaluate the rigor and success of FSM courses, we conduct short learning assessments (15-20 minutes long) at the beginning and end of our courses to measure student understanding of the key concepts in each class. We also conduct surveys with the students and instructors to collect demographic data and feedback on the effectiveness of and experiences provided by the program. We use these assessments and surveys to gauge student learning (summative) as well as to improve future iterations of the program and each course (formative). Below, we present our most recent findings and discuss their implications with respect to the strengths, limitations, and relative merits of programs like FSM, which are rare or otherwise poorly represented in the literature.

## **Program Demographics, Learning, Assessments, and Student Evaluations**

### *Demographics*

When students registered for FSM during the summers of 2016 and 2017, we collected demographic data on their grade level, race/ethnicity, gender, parent's educational attainment, and whether or not they received free or reduced price meals at school. Approximately 84% of the students who participated in the program were in high school (i.e. grades 9-12), with students entering the 9th, 10th, and 11th grades comprising the majority and enrolling at relatively equal rates (33.0%, 27.0%, and 18.1%, respectively; Figure 1A). Students entering the 12th grade, however, constituted only 6.3% of enrollees. Despite the FSM program being targeted primarily at high school students, middle school students (i.e. grades 6-8) made up a substantial proportion of the remaining participants in the program (15.6%), the majority of these entering the 7th and 8th grades (5.6% and 9.3%, respectively; Figure 1A). Students predominantly identified as White, not Hispanic, with approximately 35% identifying as other races/ethnicities (Figure 1B). The distribution of races/ethnicities that enroll in FSM courses aligned well with the Bloomington, IN demographic data obtained in the 2010 census (United States Census Bureau, 2010), indicating that FSM attracts a representative sample of students from the local community. Further, males (50% of FSM students) and females (50%) are equally represented across the program.



**Figure 1. Demographic data on student grade level and ethnicity in summers 2016 and 2017. (A)** The majority of students enrolled in FSM are preparing to enter grades 8-11 in the fall, whereas less than 15% of those enrolled will be entering grades 6, 7, and 12. **(B)** The distribution of races/ethnicities that enroll in FSM courses.

While the FSM program as a whole has been very successful at attracting an equal amount of males and females (50/50 split), as well as ratios of minority students consistent with the local demographics, we observed that specific courses fail to recruit students from all backgrounds equally. For instance, less than 25% of students that enrolled in Introduction to Programming and Astrophysics for Beginners during summers 2016 and 2017 identified as female. Conversely, a disproportionately high number of female students enrolled in Brain Science, Forensic Science, and Zoology. Students who identified as African American, Native American, or Latino were underrepresented in Algebra 1, Introduction to Universe, and Astrophysics for Beginners, comprising <5% of enrollees in each. Thus, directed recruitment initiatives may be necessary to promote equitable representation across courses.

Approximately 92% of students have at least one parent with an associate's degree or higher. However, only 50% of children across the United States reside with a parent who attained a this level of education or higher (National Center for Education Statistics, 2016). Further, only 13% of the students who enrolled in FSM reported receiving free- or reduced-price meals at school, but 48% of students across the state of Indiana qualify (Indiana Youth Institute, 2018). The disproportionately low enrollment of students who do not have parents with a college degree and students who are eligible for free or reduced meal prices at school is likely due to several factors, including the fact that FSM is extensively advertised to Indiana University faculty and staff. This illuminates the need for expanded community outreach to better include households from all educational and financial backgrounds (see Raising Community Awareness below).

### *Learning Assessment*

To assess academic improvement, we administer identical pre- and post-tests to students on the first and last (i.e. sixth) day of each course, respectively. Each course has a unique test designed to address that course's core concepts, and instructors are encouraged to incorporate content from all six class sessions into the test whenever possible. Pre- and post-test questions are composed of problems taking a variety of forms, including true or false, matching, multiple choice, and free response. Tests range from 10-15 questions and students are given 15-20 minutes for completion. Because instructors are encouraged to modify courses' syllabi as they deem necessary, pre- and post-tests for identically titled courses varied across sessions and summers. To evaluate whether students showed significant improvement between pre- and post-tests from 2011-2017, we conducted paired, two-tailed t-tests or alternatively the non-parametric Wilcoxon signed-rank test where assumptions of normality and homoscedasticity were violated ( $N = 8$  courses total). In addition, we used an unpaired, two-tailed t-test to assess whether academic improvement differed significantly between previously ( $N = 18$ ) and newly ( $N = 9$ ) designed courses in 2016 and 2017. Test data from classes taught in both sessions

of a given summer were combined for analysis. Sample sizes for each class ranged from 1 to 26; however, we did not analyze courses with fewer than three respondents. All analyses were conducted in SigmaPlot statistical software v. 12.5 (Systat Software, Inc.).

We found that test scores improved by 22% on average from 2011-2017, with average pre- and post-test scores of 45% and 67%, respectively. The effect size of this improvement was large, with a Cohen's D value of 2.49, indicating that the difference between the two mean test scores is greater than two standard deviations. Among science courses, we found that 32/37 (86.5%) showed statistically significant improvement. Students in mathematics showed significant improvement in 11/19 (57.9%) courses (Table 1). Among those courses that did not significantly improve, two of the science and six of the math courses were offered in 2016-2017 (see below for discussion). However, we found that there was no difference in student learning between newly (new for 2016/17) and previously established courses ( $t = -0.130$ ,  $p = 0.897$ ).

Overall, these results demonstrate that, during the last seven years, the FSM program has been generally successful in i) establishing courses with content that is challenging but not completely unfamiliar to students, as evidenced by the 45% average pre-test scores, which suggest some initial level of competency, and ii) that students increase their knowledge of the course material by the equivalent of two letter grades on average (i.e. 22%;  $D = 2.49$ ). Therefore, FSM courses consistently improved student knowledge, and generally maintained this standard while adding a series of new and unique courses to its offerings. However, it is important to note that these gains are not equally distributed among course disciplines, with the number of courses demonstrating significant improvement in test scores being ~30% lower in mathematics relative to the sciences. Among the eight mathematics courses that did not show improvement during the past seven years, 75% of these were held in 2016 and 2017 (Table 1). We suggest that this may be due to two factors. First, in recent years, all mathematics courses were taught primarily by graduate students with backgrounds in mathematics, but recruited from non-mathematics departments, such as psychology and music theory. As such, they may be underprepared to teach mathematics in this type of setting (McGivney-Burelle et al., 2001; Harris et al., 2008), and in each case these courses were taught by a single instructor who lacked the benefit of feedback from a peer co-instructor. Second, we saw substantial turnover in mathematics instructors since 2015, making it difficult for instructors and their courses to improve across summer sessions and years. Recognition of these challenges led to recent structural changes in the FSM program in recruiting appropriate instructors, retaining those with experience, and providing training and peer feedback for those who are inexperienced (see below).

Table 1.

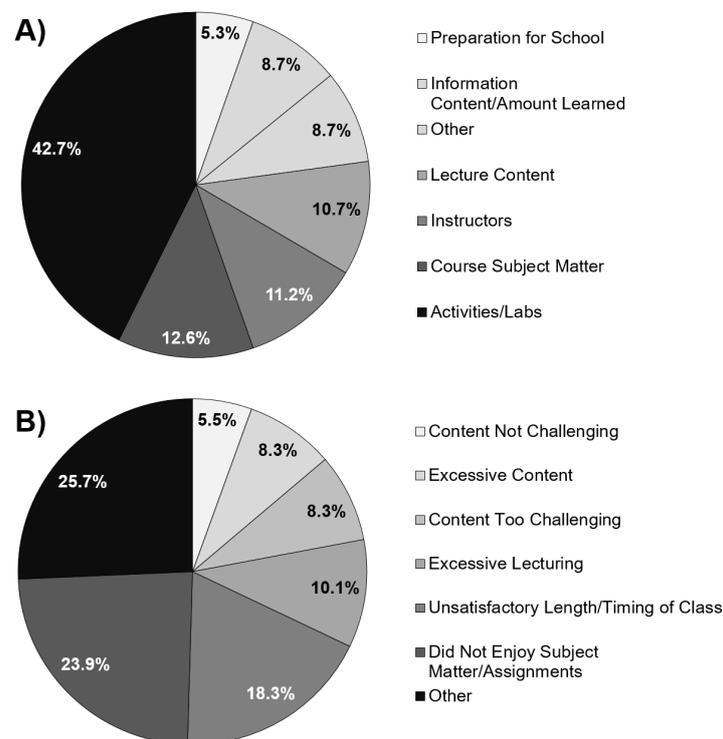
Gains in student learning from 2011-2017. Included are the names of each math and science class, number of students from which pre- and post-test data were collected, the mean or median gain, and the *p*-value to indicate whether those gains were statistically significant for all years. Empty spaces indicate years in which a class was not taught or data were not collected. Dashed lines replace *i*) gains where only raw scores, but not percentage scores, were available, and ii) *p*-values where sample size is less than three. Overall, students significantly improved their test scores in 43 courses.

	2011		2012		2013		2014		2015		2016		2017					
	N	P	N	P	N	P	N	P	N	P	N	P	N	P				
Advanced Biology	8	12.9%	0.001								16	20.4%	<0.001	8	26.1%	0.002		
Advanced Chemistry	4	-	0.036															
Advanced Physics	3	12.0%	0.075	4	8.0%	0.165												
Astronomy				7	34.3%	0.011	6	29.8%	0.004									
Astrophysics																		
Brain Science														21	12.5%	0.025		
Chemistry in Food														4	28.7%	0.002		
Computer Science				26	26.4%	<0.001												
Forensic Science																		
Introductory Biology				12	16.3%	0.001	12	-1.5%	0.535	16	24.2%	<0.001	11	22.8%	<0.001	12	19.1%	0.008
Introductory Chemistry				17	-	<0.001				16	19.8%	<0.001	17	26.6%	<0.001	10	13.1%	0.057
Introductory Physics				18	20.6%	<0.001	13	24.2%	<0.001	2	20.0%	-	11	30.2%	<0.001	13	20.0%	0.004
Introduction to Universe	17	20.2%	<0.001				7	22.1%	0.003							8	18.4%	<0.001
Our Evolving World																6	13.3%	0.117
Zoology																6	17.0%	0.031
Advanced Pre-calculus				3	22.2%	0.138	2	23.6%	-									
Algebra I																		
Algebra II																13	10.0%	0.375
Calculus	6	21.7%	0.021	9	20.7%	0.021	8	24.1%	0.005	5	7.7%	0.090				14	5.7%	0.135
Mathematics Problem Solving				6	32.1%	0.004	6	32.1%	0.004							9	31.7%	0.007
Pre-calculus	17	32.1%	<0.001	16	43.2%	<0.001	10	24.3%	0.002	8	30.7%	0.006						
Std. Test Math Review																7	11.4%	0.569
Trigonometry																6	23.4%	0.135
																3	4.2%	0.789

### Student Course Evaluations

We distributed an exit survey alongside each post-test in the last 30 minutes of the final (i.e. sixth) class of each course. The structure of this survey was maintained across all courses, and was divided into two sections. In the first section, we asked students to evaluate their experience in the course on four criteria, including whether: i) they enjoyed the course, ii) they found the course useful, iii) they found their instructor(s) knowledgeable, and iv) their overall impression of the FSM program. For each of these questions, students were asked to rank their response from 1 (lowest value) to 4 (highest value). In the second section of the survey, we asked students to identify their favorite and least favorite aspects of their course via free response. These responses were coded and binned into seven categories for both 'favorite' and 'least favorite' responses. Here, we combined responses to both questions and comments from all math ( $N = 14$ ) and science ( $N = 29$ ) classes conducted only during summers 2016-2017, and present student rankings from 2011-2017.

When students in the 2016-17 cohort were asked what they enjoyed most about their courses, 88 (42.7% of those who responded) said that they enjoyed the activities and laboratory-based assignments, primarily highlighting their interactive nature and utility in helping to clarify challenging concepts (Figure 2A). Further, students frequently (12.6%) listed the general subject matter of their course, as many FSM classes provide students the opportunity to learn about topics not accessible at their base school. Additionally, students listed their instructors (11.2%), the lecture content (10.7%), the amount of content in the course (8.7%), and the ability of the course to prepare them for fall classes (5.3%) as being major sources of enjoyment (Figure 2A). Conversely, when asked what they enjoyed least about their course, 26 students (23.9%) responded that they did not enjoy the topic of their course, or found the tests, surveys, homework, and lab activities to be burdensome (Figure 2B).



**Figure 2. Student favorite and least favorite aspects of each course.** (A) Students most frequently listed class activities and laboratory assignments as their favorite component of each course. (B) At the same time, half of all students listed their least favorite component as being i) the tests, surveys, homework, and lab activities and the subject matter, or ii) some other aspect of the course (e.g. other students, the room the course was held in, question and answer discussions)

Further, a large proportion of students (18%) found the length or timing of their course unsatisfactory, primarily complaining about courses that started early (i.e. at 9am) and the two hour length of each class. Though early starting times are somewhat unpopular with students, program administrators are hesitant to change the start times, which are both necessary for FSM to offer as many courses as it does, and are preferable to many parents (Wahlstrom, 1999; Wahlstrom et al., 2014; Troxel and Wolfson, 2017). Finally, students listed excessive lecturing (10.1%) and course content (e.g. particular lecture topics; 8.3%), as well as content being either too challenging (8.3%) or not challenging enough (5.5%) as being additional sources of frustration or disappointment (Figure 2B). For all survey questions, we found that students rated FSM an average of 3.0 or higher on all survey items since 2015, with 2016 and 2017 having the highest scores since the program began in 2011 (Table 2). These results suggest that students feel positively about the program.

Table 2.

*Student assessment of FSM program from 2011-2017.* Included are seven survey questions presented to students at the end of each FSM course. Ratings range from 1 (lowest) to 4 (highest). Dash marks indicate questions that were not asked in a particular year. No surveys were administered in 2014. With the exception of 2012 and 2013, students ranked FSM a 3 or above in all criteria each year.

	Year						
	2011	2012	2013	2014	2015	2016	2017
Did you enjoy the class?	3.14	2.92	2.87	-	3.05	3.13	3.12
Was this class useful?	3.25	2.94	2.93	-	3.16	3.21	3.18
Was the instructor prepared and knowledgeable?	3.68	3.60	3.40	-	3.58	3.53	3.48
Did the instructor communicate effectively?	3.69	3.50	3.43	-	-	-	-
Overall, how would you rate your instructor?	3.69	3.64	3.62	-	-	-	-
Overall, how would you rate this course?	3.43	3.33	3.39	-	-	-	-
Overall, what is your impression of this summer program?	3.35	3.12	3.18	-	3.26	3.33	3.38

In combination, the findings from our demographic data, learning assessments, and survey results suggest that the FSM program has and will continue to reach a substantial audience of students, that these students generally enjoy the classes they take, and that they learn a great deal within only six days of instruction. We strongly feel that the FSM model for graduate student-driven outreach and the community connections that it generates, can be readily reproduced at a wide range of higher education institutions. Below, we detail how similar programs can be initiated and maintained at other institutions, and reflect on what we learned regarding i) how to fund and maintain such a program, ii) how to recruit, retain, and train graduate student instructors, and iii) the best practices for eliciting community involvement and support for such a program.

## Recommendations for Implementation at Other Institutions

### *Funding, Growth, and Program Maintenance*

In recent iterations, FSM operated on a budget of approximately \$11,000 per year, with personnel stipends accounting for approximately \$9,500 of the budget (\$250 to instructors per course taught and \$250 per administrator). The remaining budget was used to purchase supplies (\$1,000) and to advertise the program (\$500; see below). A survey of our graduate student instructors (N = 32), however, indicates that most instructors (70%) would teach without any compensation, though fewer instructors would be willing to design a novel course (55% total). Thus, the potential exists to create and operate an FSM-like program on a budget of less than \$2,000 in the event that funds are limited.

We acquire funding from several sources, including approximately 35% of our budget from local, regional, and national granting agencies (e.g. the Indiana University Women's Philanthropy Leadership Council, the Indiana Space Grant Consortium, and the Society for the Study of Evolution) as well as 35% of our budget from the Indiana University Colleges and Departments from which we recruit graduate student instructors.

The remaining 30% of our budget is funded by modest enrollment fees (these varied between \$25 and \$35 per course) which serve both as a source of income for the program and help to ensure attendance of the students who enroll. For instance, in the the summer of 2017, we offered free registration to the Our Evolving World course and a large number of enrollees never attended. This not only made planning difficult for the instructors but also potentially prevented enrollment of other students who would have participated if not for our limits on class size (i.e. fifteen students). Thus, should an FSM-like program be put into effect, we recommend implementing a nominal registration fee to discourage neglectful enrollments.

#### *Recruiting, Maintaining, and Training Graduate Student Instructors*

Graduate student instructor recruitment is one of the most important duties in maintaining the FSM program. These efforts are driven primarily through a call-out meeting advertised to all relevant departments at the beginning of each academic year, though often times positive word-of-mouth leads potential instructors to contact program administrators directly. The graduate student instructors are paid a small stipend (\$250), but potential instructors are often driven by opportunities to develop curricula, direct education research, participate in grant-writing, gain administrative experience, and take advantage of in-class teaching opportunities that might otherwise be unavailable in a traditional graduate education (Davis and Kring, 2001; Cherrstrom et al., 2017). As a result of its popularity, FSM administrators have, at times, had to turn away ambitious graduate students due to an overabundance of instructors, particularly in the natural sciences (see more below).

Although the FSM program was met with enthusiasm by the graduate student community, it has been difficult to recruit instructors from some academic departments, such as Computer Science and Mathematics. Other departments, such as Biology, have long had larger pools of willing graduate-student participants than instructor vacancies. We suspect that some of this disparity is due to different summer research expectations and demands by these departments, the importance of participating in external private internships during the summer, as well as the availability of summer funding, for which the modest FSM instructor stipend makes only a small contribution. However, while for most disciplines it is rarely challenging to find available and qualified graduate students, perhaps the greatest obstacle for the continuation and growth of FSM has been the regular turnover of talented instructors, which appears to be driven primarily by instructor obligations in their research laboratories and other academic conflicts. For instance, in summer 2017, 75% of all instructors were new to the FSM program, and only 60% of instructors indicated that they would participate in the next summer. Among those who would not be participating, 80% indicated that they would be graduating, preparing for preliminary examinations or expected a scheduling conflict. Although turnover is high in the FSM program, this is not due to a lack of incentive to participate or instructor dissatisfaction with their experience.

For the first five years of the FSM program, instructors received no direct training or feedback from program administrators or peers within their academic discipline, with feedback derived solely from student course evaluations. However, instructors at Indiana University have benefitted from graduate-level coursework in research-based teaching methods offered at the university, including a class offered by one of the authors (Maltese) entitled University STEM Teaching. This model of allowing graduate students to develop their own curricula, manage their classrooms, and make adjustments where appropriate has long been highlighted as a major factor in recruiting graduate students to the FSM program. Indeed, as of 2017, 90% of FSM instructors feel that participation in FSM improved their teaching skills, and 70% indicated a greater interest in pedagogy and teaching due to their participation in the program. The low improvement scores in a subset of recent mathematics courses, however, makes it clear that some instructors are likely poorly prepared to design or independently instruct a course. Whether this is due to high instructor turnover or the increasing demands on mathematics instructors that came with the rapid growth of FSM is not clear. In an attempt to remedy this situation, FSM instituted a policy in 2017 mandating meetings with all instructors in science and exploratory courses in order to modify and improve both longstanding and novel courses through peer review prior to the beginning of each summer session. These interventions likely explain the initial success of the newly designed courses and are now being applied to the mathematics program. In addition, where instructors are available, we attempted to assign two instructors to each classroom and pair less experienced instructors with more

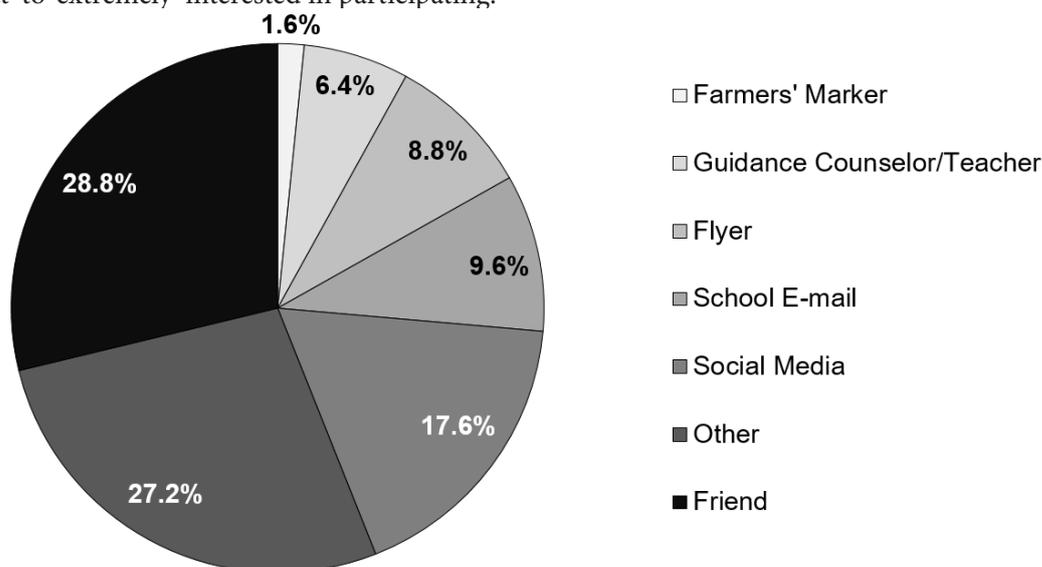
experienced peers (i.e. 1+ year of program experience). Finally, Indiana University has a number of programs in place, such as pedagogy courses, the Center for Innovative Teaching and Learning, and other training opportunities where FSM instructors can learn strategies and invite those with expertise to observe and critique their courses and curricula.

*Raising Community Awareness*

Among the various tasks involved in maintaining and growing the FSM program, perhaps the most time-intensive has been raising community awareness through graduate student-led outreach. These efforts span an approximately seven-month period (i.e. December – June), and taken a variety of formats, ranging from designing and hanging flyers, outreach at local venues (e.g. science fairs, museums, farmers’ markets), and digital correspondence (e.g. via e-mail, social media).

Efforts to advertise the FSM program begin in earnest each December with the designing of the annual flyer, detailing the courses offered, prices, time and location of the program. By February, program administrators begin posting these flyers throughout the community, including local businesses, churches, the county and campus libraries, heavily trafficked parts of our university campus, and museums. By March and April, e-mails advertising the program are sent to parents of past FSM students as well as university faculty and staff. In parallel, schools are contacted with a request that flyers be placed in hallways and classrooms by school staff, and this is followed-up with individualized e-mails to all math and science teachers, as well as guidance counselors at these schools. In combination, these efforts yielded approximately 25% of all 2017 registrations (see Figure 3 for additional sources of registration). Throughout this time period, we use digital advertising to reach potential FSM parents and students. Specifically, we post our flyer on an online bulletin board maintained by the local community school corporation, and use outreach funds to post paid advertisements to social media websites (yielding ~18% of all registrations; Figure 3).

In May, approximately one month prior to the beginning of classes, we attempt to more directly interface with the community by holding informational meetings about the program, while also performing scientific demonstrations and passing out flyers at the community farmers’ market. These sustained and thus far highly successful outreach efforts required a great commitment of time and energy from FSM administrators and course instructors, who are generally enthusiastic about participating. Indeed, when asked if they would be willing to contribute to program outreach in the next year, 72% of instructors indicated that they would be ‘somewhat’ to ‘extremely’ interested in participating.



**Figure 3.** How students and parents hear about the FSM program. More than half of all parents and students hear about FSM through friends or other sources (e.g. web search, IU website), whereas the other half hear about the program through social media, e-mails from the school, flyers, guidance counselors/teachers, or the farmers’ market.

One of the longstanding goals of the FSM program is to provide greater access to this program for traditionally underserved and disadvantaged groups. To do so, we began to take a more targeted outreach approach by partnering with community groups. Specifically, we are offering pre-enrollment and fee remissions to members of local youth organizations focused on supporting girls, minorities, and low income families, such as the Girl Scouts, Girls Inc., and the Boys and Girls Club. We hope that by directly advertising to these groups and decreasing the financial burden of participating in our program for those that need it, we can increase the exposure of our program within the community and better serve students from all backgrounds.

### Conclusions and Future Directions

Across seven years of growth and development, the Foundations in Science and Mathematics program has continually sought to provide a mutually beneficial setting in which secondary students can explore scientific and mathematical concepts in a collaborative, active learning environment, and graduate students can develop their pedagogical, administrative, and science communication skills (Tanner and Allen, 2006). Based on quantitative assessments of student learning, as well as student and instructor course evaluations, it is now clear that this program is achieving these goals, and in so doing promoted collaboration between IU and local educational institutions and community organizations. These achievements have likely come as a result of successful funding strategies, effective management and the development of substantial program infrastructure, as well as a reliance on active learning strategies (Prince, 2004; Freeman et al., 2014), all of which are the product of graduate student efforts since 2011.

At the same time, we identified several challenges associated with maintaining a program such as FSM, including the need to train and retain talented graduate students, to collaboratively revise curricula to incorporate active learning that can better foster student learning (Freeman et al., 2014; Schwartz et al., 2016), and to more effectively perform outreach to disadvantaged communities. At the same time, although taking an active learning approach has been successful, we hope to incorporate inquiry-based approaches that span the duration of each course, as individual two hour classes make this approach difficult to incorporate. Despite these challenges, we feel that FSM has great potential for future growth, and believe strongly that expanding this model to additional colleges and universities holds great promise for reaching larger and more diverse communities of young learners and future STEM professionals (Kitchen et al., 2018). We therefore urge interested parties to contact us through our website (i.e. <http://www.indiana.edu/~fsm/>) or via e-mail ([fsm@indiana.edu](mailto:fsm@indiana.edu)) in order to explore this possibility.

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