Urban High School Teachers` Experiences in an IT/STEM Summer Course: Gaining Knowledge and Skills, Preparedness to Use, Evaluation

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Abstract: This exploratory study examines the impact of an IT/STEM summer course on STEM high school teachers' knowledge and skills to design and deliver IT/STEM enrichment experiences for their students. The study describes and reports on the findings of an IT/STEM summer course that included 14 high school STEM teachers. Data were collected from pre and post surveys, in-class observations, document analysis, and end-of course evaluation questionnaire. Findings indicate that teacher participants improved their IT/STEM knowledge and skills throughout the course. There was limited improvement with respect to preparing participating teachers to facilitate IT/STEM teaching/learning strategies over the course of the summer course. The study demonstrates that teachers need more extensive enrichment experiences to increase their knowledge and skills to design and deliver IT/STEM learning experiences for students.

Introduction

The study presented in this paper is part of the Fostering Interest in Information Technology (FI^{3}T) program, which is a three-year project funded through the National Science Foundation (NSF)'s Innovative Technology Experiences for Students and Teachers (ITEST) program. FI^{3}T provides opportunities for underrepresented and underserved high school students and their teachers to learn about and use information technology (IT) in the areas of science, technology, engineering, and mathematics (STEM). Students and teachers collaborate directly with higher education faculty, graduate students, and business partners in learning about, designing, and implementing IT-supported STEM activities and projects. The *Community of Designers* approach introduced by Mishra, Koehler, & Zhao (2006) provides a basis for such a collaborative partnership.

One specific program objective of the FI^{3}T project is to increase STEM high school teachers' knowledge and skills to design and deliver IT/STEM enrichment experiences for their students in classroom and after-school settings. The work of FI^{3}T for this specific goal is accomplished over a two-year cycle through summer and school-year experiences. The cycle starts with an IT/STEM intensive summer course for a cohort group of high-school STEM teachers to provide them concentrated IT/STEM experiences in order to build their knowledge and skills to learn various IT/STEM technologies, both hardware and software, and how to help their students learn to use them. After the summer course, for selected group of teachers, the cycle continues with access to year-round enrichment experiences over two years. The course allows FI^{3}T project leadership to observe participating teachers` performances during the course and select one qualified teacher for each STEM area for the program's continuing year-round enrichment experiences where they collaborate with higher education faculty, graduate students, and business partners to facilitate school-year IT/STEM workshops and IT-supported STEM project activities for high school students participate in the FI^{3}T program, and other students in their own schools. Through their extended experiences, these selected core teachers serve in the leadership positions and mentor remaining summer course teacher participants for their further professional development in IT/STEM areas.

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Because the two-year cycle has not completed for project's participating teachers and the pre and post data is only available from the initial IT/STEM summer course this paper describes and reports on the findings of the IT/STEM summer course focusing on the following three questions:

1. What was the impact of the IT/STEM summer course on STEM high school teachers' IT/STEM knowledge and skills?

2. What was the impact of the IT/STEM summer course on STEM high school teachers' preparedness to use specific IT/STEM teaching/learning strategies?

3. What was the STEM high school teachers' evaluation of the IT/STEM summer course?

In the following sections, we first describe the IT/STEM summer course investigated in this study. We then describe the study that used multiple methods to determine the impact of the IT/STEM summer course. In the subsequent section, we present the study findings accompanied by a discussion of those findings. In the conclusion section, we identify and discuss ways in which the IT/STEM summer course impacted high school STEM teachers' knowledge and skills to design and deliver IT/STEM enrichment experiences for their students.

IT/STEM Summer Course

The IT/STEM summer course is a one-semester three credit-hour graduate level course. The course is organized around the four STEM fields to provide teachers with concentrated IT/STEM experiences in order to build their knowledge and skills to learn various IT/STEM technologies, both hardware and software, and how to help their student learn to use them. Four different STEM area faculty (one for each STEM area) teach the course together over two weeks in summer term where each has 12 contact hours with teacher participants. The *science* part concentrates on three different but related applications of IT in the sciences; measurement, modeling, and mapping. Participating teachers' learning experiences for IT/Science includes making location measurements using GPS and integrating the measurements in a GIS system, using temperature and light sensors in the sciences, and creating mathematical models using STELLA that incorporate measured quantities and make predictions. The *technology* section focuses on technological tools and languages for designing and developing Web applications such as Web-based games and chat-rooms. Participants gain experiences with the basics of visual programming, familiarize themselves with integrated development environments such as Visual Studio and Alice, and practice designing and developing games. The *engineering* component emphasizes the basics of robotics and its applications as related to IT, including modeling robots, programming robots, and integrating robots into an application environment such as a manufacturing system or a medical application. Engineering related learning experiences involves using robotics simulation software packages such as IGRIP and ROBCAD, learning the basics of robotics such as modeling and programming robots, and learning integration of robots in an application environment such as manufacturing system or surgery operating room. The *mathematics* piece focuses on statistical science with consideration of the two-sample comparison problem, the simple regression/correlation problem, and the simple analysis of covariance problem taking examples and assignments from public health science, environmental science, and manufacturing reliability. Participants use Minitab to create comparative displays and regression displays and perform appropriate analysis to test for and estimate effect sizes.

The Study

Research Design

A mixed methods design was used in this study combining both quantitative and qualitative data collection and analysis. As Gay, Mills, and Airasian (2006) describe, mixed methods research combines both quantitative and qualitative data collection and analysis in a single study. The use of descriptive, interpretive, and evaluative components of this study required a combination of quantitative and qualitative research methods in order to appropriately answer the research questions. The first step of the study involved the dissemination of a pre-course survey about participants' IT/STEM knowledge and skills and preparedness to use specific IT/STEM teaching/learning strategies. The second step included observations in various class sessions to better understand the nature of the course being offered to teacher participants. The third step involved the administering of the post-course survey, and an end-of-course evaluation questionnaire about participants' experiences in the course.

Participants and Setting

The subjects for this study included 14 STEM teachers from a major Midwest urban school district. A total of 15 teachers were recruited by the FI^3T project management team, using a competitive application system. Thirty-nine (39) teachers applied to participate; 26 attended a required group interview conducted by the management team. Of those, fourteen (14) met selection criteria; 12 completed the two-week course. The fourteen were from 9 different high schools and one (1) middle school in the participating school district.

Instrumentation

A survey designed by the project's external evaluator was used to evaluate the project participants' IT/STEM knowledge and skills and preparedness to use specific IT/STEM teaching/learning strategies. Teachers were asked to rate their skills/knowledge in using specific technologies on a 4-point scale, with 1 = weak skills/knowledge and 4 = strong skills/knowledge. Teachers were also asked to rate their preparedness to facilitate particular teaching/learning strategies at their grade level on a 4-point scale, with 1 = not adequately prepared and 4 = very well prepared. At the end of the two-week session, teachers were asked to complete an end-of course evaluation questionnaire about their experiences in the course. Teachers were asked to rate the major course objectives according to 1) their perception of the *value* of the course and 2) whether they thought it was *accomplished*, with a 1 = low rating and 5 = high rating. Teachers were also asked to rate the usefulness of course activities in helping them facilitate STEM-related activities/projects with their students on a 5-point scale, with 1 = low rating and 5 = high rating. An observation protocol is developed based on the state and national standards for teacher professional development and used for in-class observations.

The external evaluator reported successful and satisfactory use of the survey and the end-of-course evaluation questionnaire employed in this study for a number of years in different professional development programs confirming their reliability. Additionally, a panel of experts in IT/STEM areas reviewed and revised the instruments for content validity.

Data Collection and Analysis

Various forms of data were collected related to each of the research questions. A combination of quantitative and qualitative methodologies were employed, including (a) quantitative data collected from the pre- and post surveys, and end-of-course evaluation questionnaire (b) qualitative data collected from in-class observations and document analysis (e.g., course syllabi). The research questions drove the data analysis. The data were acquired through the survey administered twice in a pre-test/post-test design. Descriptive statistics were used to compare the means for the same variable measured at two time points (e.g., pre-test and post-test) on the same set of subjects. Descriptive statistics were also used to analyze results from the end-of-course evaluation questionnaire. A total of six class sessions were observed by the project's external evaluator during the summer course. Each of the sessions observed were facilitated by a different faculty member or subject-matter expert. Observation data was analyzed based on session organization, implementation, content, and climate/culture.

Limitations

The present study has some limitations that need to be taken into account when considering the study and its contributions. A total of 14 participants in the study is characteristic of what might be considered a pilot in preparation for a more extended study. The long term impact of the study needs to be seen because the two-year cycle has not completed for participants where they have continuing year-round enrichment experiences.

Findings

IT/STEM Knowledge and Skills

At the beginning of the summer course and again at the end, teachers were asked to complete an 11-item survey about their IT/STEM technology knowledge and skills. Teachers rated their skills/knowledge in using specific technologies on a 4-point scale, with 1=weak skills/knowledge and 4=strong skills/knowledge. Fourteen (14) teachers completed the pre-course survey; 11 completed the post survey. Table 1 below shows the skills/knowledge categories and pre and post survey mean scores, and mean ranges.

Table 1: *IT/STEM Knowledge and Skills.*

Knowledge/Skills	Pre Mean	Post Mean	Mean Range
a. GPS/GIS for mapping	1.57	3.00	1.43
b. GPS/GIS to create mathematical descriptions	1.14	2.82	1.68
c. Use of temperature/light sensors for data collection	2.50	3.18	0.68
d. Use STELLA computer program to explore mathematical modeling of environmental variables	1.07	3.09	2.02
e. Design and develop games using visual studio	1.21	2.18	0.97
f. Understanding of fundamentals of robotics and robotics applications	2.07	2.82	0.75
g. Use robotics and robot computer programming language	1.86	2.82	0.96
h. Applying robotics technology into real-world situations, such as manufacturing system or surgery operating room	1.86	3.09	1.23
i. Basic statistical analysis procedures	2.50	2.82	0.32
j. Minitab statistical software to create comparative displays and regression displays to conduct statistical tests	1.14	2.91	1.77
k. Writing reports based on data analysis from scientific studies	2.57	3.18	0.61
Overall	1.771	2.900	1.129

As shown in Table 1, the results indicate increase in mean scores from pre-survey to post-survey for each item tested on the survey indicating that throughout their participation in the IT/STEM summer course participants improved their IT/STEM skills and knowledge in each item tested on the survey. The largest increase was made for using STELLA computer program to explore mathematical modeling of environmental variables with 2.02 mean range. Similar changes were made for using Minitab to create comparative displays and regression displays to conduct statistical tests, and using GPS/GIS to create mathematical descriptions. Participants increased their use of GPS/GIS for mapping and applying robotics technology into real-world situations. Scores for other items tested on the survey showed relatively low increase in mean scores over the course of the IT/STEM summer course where as all post-survey mean scores for each of these cases were larger than the mean pre-survey scores.

Preparedness to Use Specific IT/STEM Teaching/Learning Strategies

At the beginning of the summer course and again at the end, teachers were asked to complete an 11-item survey about their preparedness to use IT/STEM specific teaching/learning strategies. Teachers were asked to rate their preparedness to facilitate particular teaching/learning strategies at their grade level on a 4-point scale, with 1 = not adequately prepared and 4 = very well prepared. Table 2 below shows strategy categories and pre and post survey mean scores including the mean ranges.

Table 2. *Preparedness to Use Specific IT/STEM Teaching/Learning Strategies*

Teaching/Learning Strategies	Pre Mean	Post Mean	Range
a. Problem-solving among students	3.57	3.73	0.16
b. Making connections between information technology (IT) and science, math, technology, and engineering topics	3.07	3.45	0.38
c. Making connections within and between science, math, technology, and engineering topics	3.14	3.55	0.41
d. Making connections from science, math, technology, and engineering to real-world situations	3.29	3.64	0.35
e. Leading a class of students using investigative strategies	3.29	3.73	0.44
f. Managing a class engaged in hands-on /project based work	3.64	3.91	0.27
g. Helping students use IT to conduct investigations	2.93	3.55	0.62
h. Helping students take use IT to design programs and systems	2.36	3.36	1.00
i. Helping students use technology to present findings from their investigations	2.93	3.55	0.62
j. Helping students take responsibility for their own learning	3.50	3.64	0.14

k. Writing modules/units that other teachers can use to increase their use of IT to support science, technology, engineering, and mathematics activities in the classroom	2.50	2.91	0.41
Overall	3.110	3.547	0.436

As shown in Table 2, the results indicate that throughout their participation in the IT/STEM summer course participants improved their preparedness to facilitate specific IT/STEM teaching/learning strategies at their grade in each item tasted on the survey. With largest mean range showing 1.00, the results also indicate relatively low increase in mean scores from pre-survey to post-survey for each item tested on the survey where as all post-survey mean scores for each of these cases were larger than the mean pre-test scores. This low increase in mean scores over the course of the IT/STEM summer course might be related to relatively large mean scores that pre-survey showed for each item tested on the survey. It appears that, at the beginning of the summer course, to some degree, participants were already familiar with and prepared to facilitate particular teaching/learning strategies at their grade level. Or, it might be the case that IT/STEM summer course provided limited expereinces with respect to preparing teacher participants to facilitate specific IT/STEM teaching/learning strategies in the classroom.

Organization, Implementation, Content, Climate/Culture

Analysis of the qualitative data collected through in-class observations provided the data useful to understand the nature of the IT/STEM course being offered to teacher participants. Analysis of observation data related to session organization, implementation, content, and climate/culture indicate that there was great variability across the sessions. Some reflected collaborative working relationships between facilitators and participants; others were more consistent with traditional college lecture-based courses. It appears that most of the facilitators had only limited experience facilitating course or professional development for practicing classroom teachers; they appeared more accustomed to working with traditional college students rather than the teacher who had significant classroom experiences themselves. Over the course of the summer course, the facilitators recognized the need to adjust their sessions to better meet the needs and learning styles of the teachers. This recognition was evidenced by the project leadership in observing discussions during management team debriefing/planning meetings.

Evaluation of the IT/STEM Summer Course

At the end of the summer course, teachers were asked to complete an end-of course evaluation questionnaire about their experiences in the course. Teachers were asked to rate the major course objectives according to 1) their perception of the *value* of the course and 2) whether they thought it was *accomplished*, with a 1 = low rating and 5 = high rating. Ten of the 12 teacher participants completed the questionnaire. Descriptive analyses of the data indicate that most of the teachers think that the course was valuable for them and achieved its objectives. Of the 10 major objectives identified by course facilitators, mean score ratings for value ranged from 4.11 to 4.78 and for accomplishment from 3.40 to 4.50.

Results also indicate that most of the teachers (seven of the 10) think that the course met their expectations. Overall comments participant teachers placed on the questionnaire indicated that they "*exposed to a lot of wonderful information and learned so much.*" Some others indicated that *"the summer course was very intense, beyond [their] expectations—too much information was being delivered in a very short time."*

Teachers were asked to rate the usefulness of course activities in helping them facilitate STEM-related activities/projects with their students on a 5-point scale, with 1 = low rating and 5 = high rating. Table 4 below shows major course activities and mean ratings.

Table 4: *Ratings of the Usefulness of Course Activities*

Activity	Mean Rating
Making measurements with GPS	4.6
Using Google Earth as a Geographic Information System	4.9
Developing simulations with STELLA	3.9
Building and testing sensors	4.2
Using Visual Basic software	4.5

Using DirectX software to learn game programming	3.9
Programming and operating robots	4.5
Using Minitab statistical software	4.0
Writing research reports incorporating statistical data	3.7

As shown in Table 4, the results indicate that teacher participants perceived course activities as useful in general, mean score ratings ranging from 3.7 to 4.9 for nine items placed on the questionnaire for this section.

With and open ended question on the questionnaire, teachers were asked to identify possible problems they would have using technology to support their own learning or to engage students in using IT/STEM technology. Four indicated they were concerned about access to reliable technology for their students. Two indicated need for instructional materials. One was concerned about regular availability of a classroom (this person did not have their own classroom). One said, "I do not really anticipate problems because students will catch on to this much faster than I did."

Conclusions

Overall findings of the study indicate that the IT/STEM summer course achieved its major objectives and met with participating teachers` expectations. Teacher participants improved their IT/STEM knowledge and skills throughout the course. With respect to preparing teachers to facilitate IT/STEM teaching/learning strategies, results indicate limited improvement. This might be related to teacher participants' familiarity with particular teaching/learning strategies at the beginning of the course, as data suggests. Or, it might be related to the limitations of intensive summer course structure. There are indications that taking 48-hour course in two-week period was challenging for some teacher participants. Another factor might be the nature of the course with respect to the organization, implementation, content, and climate/culture. Findings indicate that there was great variability across the course sessions offered by four different STEM area faculty members. Some had only limited experiences facilitating course or professional development for practicing classroom teachers, presenting a need to adjust their sessions to better meet the needs and learning styles of the practicing teachers.

Findings of this study supports the notion that in addition to participating in an intensive IT/STEM summer course teachers need more extensive enrichment experiences to increase their abilities to design and deliver IT/STEM learning experiences for their students. Aligned with this notion, the researchers of this study plan on conducting site visits and interviews with the teacher participants to learn more about the use of IT/STEM technologies in their classrooms, as FI^{3}T program cycle continues for them in this academic year in which they collaborate directly with higher education faculty, graduate students, and business partners in learning about, designing, and implementing IT-supported STEM activities and projects for high school students.

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