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K-12 Teacher Internships: Professional Development in the Engineering Design Process and STEM Learning

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(Work in Progress)

Introduction

In today's educational system, the need for students to understand and apply formal problem solving methods is increasing. Teaching students the importance of using a formal problem solving method while demonstrating competencies associated with STEM learning concepts and 21st century skills is becoming more integrated into standards.[1,2,3,10] This is supported by some of the learning objectives integrated into the development of the Next Generation Science Standards and the Math Common Core Standards. Both of these sets of standards were developed with the recognition that the process of developing a solution is as critical of a component of learning as arriving at the solution itself. Of the two sets of standards mentioned, this is particularly evident in the Next Generation Science Standards. The Next Generation Science Standards are written with the engineering design process embedded throughout the standards to give students the opportunity to learn how a formal problem solving method increases the probability for effective solutions.[3] However, many teachers who obtained a teaching license through a traditional educational program do not have any training in the engineering design process or other formal problem solving methods.[4,13] Teacher internships have proven to be a valuable experience for giving teachers knowledge about the engineering design process and STEM learning concepts. In this paper, Bowen builds on the results of research from other teacher internship programs by focusing on how the particular internship program included in this research project may increase a teacher's use of the engineering design process and STEM learning concepts in the classroom.[4,6,7,8,9] The research questions for the current project are as follows:

1. Does the Teachers in Industry: K-12 Teacher Internship Program change teaching practices to increase the classroom use of the engineering design process?
2. Does the Teachers in Industry: K-12 Teacher Internship Program change teaching practices to increase the classroom use of STEM learning concepts?

Program Description

The Teachers in Industry: K-12 Teacher Internship program places in-service K-12 teachers into a 4-week industry work experience in a company that specializes in engineering and problem solving processes. This experience was designed to give traditionally licensed classroom teachers an opportunity to experience how corporations are currently using the engineering design process and 21st century skills to solve technological problems. Through this experience, teachers will gain knowledge about the engineering design process as well as its practical application in the workplace. One of the primary outcomes of the program is for the teacher to have an understanding about the importance of and the knowledge and skills to incorporate the engineering design process, 21st Century skills, and STEM learning concepts into general classroom teaching practices. For a complete description of the program, please refer to the article by Bowen.[4]

Methodology

To collect data for the research project, the researcher administered several surveys to collect quantitative data about the teachers' classroom practices. The questions for the survey were adapted from the Scientific Work Experience for Teachers (SWEPT) Multisite Student Outcomes Study.[5] The SWEPT Multisite Student Outcomes Study was conducted as part of an NSF Grant to research the effects of authentic research experiences for K-12 teachers.[5] The surveys used in that study consisted of questions that covered a more broad range of topics about teacher classroom practices and student engagement, a lot of which revolved around science. The researcher in the current study adapted the questions to reflect a focus on the engineering design process, as well as reorganizing some of the questions into STEM practice and concept categories. The researcher also used information from the Partnership for 21st Century Skills to develop the STEM learning and concept categories.[2]

Two different methods were used to collect and analyze the data: 1) compare pre-program surveys of past cohorts versus current cohorts of teachers, and 2) compare pre/post surveys for the current cohort of participants. The first component of the data analysis compared the effects of the program on past cohorts of teachers compared to the current cohort of teachers. This was accomplished by administering an end of school year survey to past program participants which was the same as the pre-program survey given to current participants. This was done to collect longitudinal data on current classroom practices of both teachers that have previously participated in the program versus teachers currently signed up to participate in the program. The second component of the data analysis involved determining the effects of the program on the current cohort of teachers by means of a pre and post survey. The pre-program survey, as previously mentioned, collected information about their current teaching practices in regards to the use of the engineering design process, STEM learning concepts, and 21st century skills. The post-program survey collected data on how the program affected their perception about the importance of using these concepts in the classroom and their intended change in classroom practices to incorporate more of these concepts into general teaching practices. The questions on the post-survey were structured similar to the pre-survey. However, some of the individual questions on the pre-survey were collapsed on the post-survey in order to present the options in a more categorical format. The researcher felt that since the post-survey was collecting data on intended classroom practices, the teachers may not know exactly which practices or activities they would use, but could more accurately approximate the categories or types of practices or activities they intended to use in the upcoming school year. To analyze the data collected from the surveys, a non-parametric permutation was conducted to determine if there is a significant difference between the means and standard deviation between the two groups of data. Since there were four past participants and six current participants, this type of analysis was used due to the small sample size.

Results

Table 1 shows results for the statistical analysis comparing the past and current cohorts in the actual frequency of classroom use of the engineering design process during the previous school year as well as the pre/post survey results of the current participants. The difference in means was calculated by using (past cohorts mean value minus current cohort mean value) and (pre-survey mean value minus post-survey mean value). Therefore, a positive difference in the mean values results in a higher value for past participants and pre-survey results.

Table 1

Statistical analysis comparing the current and intended frequency in classroom use of the engineering design process

	Past versus Current Participants			Current Participants (Pre/Post)		
	95% C.I.			95% C.I.		
Question	Lower	Upper	$\Delta \bar{X}$	Lower	Upper	$\Delta \bar{X}$
1 Defining a problem when given probable scenarios	-1.417	1.500	0.583	-1.500	1.500	-1.833*
2 Brainstorming	-1.333	1.583	0.917	-1.333	1.333 (Questions 2-10)	-1.452*
3 Exploring multiple possible solutions to problems	-1.583	1.750	-0.500			
4 Evaluating criteria for choosing the best solution to a problem	-1.417	1.500	1.000			
5 Building models or prototypes	-1.100	1.150	0.917			
6 Testing possible solutions to a problem	-1.450	1.700	1.333			
7 Communicating solutions to problems in written format	-0.650	0.700	1.083*			
8 Communicating solutions to problems orally	-1.700	1.450	-0.333			
9 Communicating solutions to problems by formal presentation	-2.000	2.000	0.333			
10 Reworking solutions based on self reflection or peer evaluation	-1.400	1.300	0.833			

* significance results from difference in means being outside of bootstrapping 95% C.I.

Table 2 shows results for the statistical analysis comparing the past and current cohorts in the actual frequency of classroom use of STEM classroom practices during the previous school year as well as the pre/post survey results of the current participants. The difference in means was calculated by using (past cohorts mean value minus current cohort mean value) and (pre-survey mean value minus post-survey mean value). Therefore, a positive difference in the mean values results in a higher value for past participants and pre-survey results.

Table 2

Statistical analysis on the current and intended use of STEM practices

	Past versus Current Participants			Current Participants (Pre/Post)		
	95% C.I.			95% C.I.		
Question	Lower	Upper	$\Delta \bar{X}$	Lower	Upper	$\Delta \bar{X}$
1 Lecture or whole-class direct	-1.583	1.333	-0.083	-1.167	1.083	-0.083
2 Teacher-led whole class discussions	-1.167	1.333	0.333		(Questions 1,2)	
3 Student-led whole class discussions	-1.333	1.583	0.500	-1.424	1.409	-1.758*
4 Student presentations	-0.900	0.900	0.750		(Questions 3,4)	
5 Students working in pairs	-1.333	1.167	0.083	-1.667	1.667	-1.794*
6 Students working in collaborative groups of 3-4 individuals	-1.917	1.833	0.250		(Questions 5-7)	
7 Students working in collaborative groups of 5-7 individuals	-1.050	1.200	1.250*			
8 Using inquiry based activities or discussion	-1.500	1.417	-0.167	-1.333	1.333	-1.000
9 Using hands-on project-based activities	-1.333	1.167	0.500	-1.500	1.500	-1.500*
10 Reflecting in a notebook or journal	-1.500	1.500	1.833*	-0.750	0.917	-1.333*
11 Developing a design portfolio	-1.750	2.750	2.417		(Questions 10,11)	
12 Critiquing their own work	-1.800	1.800	1.333	-1.600	1.600	-1.600*
13 Critiquing other students' work	-0.850	0.950	1.500*		(Questions 12,13)	
14 Consider a relevant real-world problem and develop a plan to address it	-1.400	1.300	0.417		(Data not available)	
15 Design or implement their own problem investigation	-1.500	1.417	1.583*		(Data not available)	

* significance results from difference in means being outside of bootstrapping 95% C.I.

Table 3 is the statistical analysis comparing the past and current cohorts on their perceived importance of a variety of STEM concepts and the importance of using these as a teaching objective. The difference in means was calculated by using (past cohorts mean value minus current cohort mean value). Therefore, a positive difference in the mean values results in a higher value for past participants.

Table 3

Statistical analysis comparing past and current participants on the perceived importance of STEM concepts

Question		Bootstrapping 95% C.I. Lower	Upper	$\Delta \bar{X}$
1	Integrating course curriculum with other subjects or fields of study	-1.000	1.500	1.000
2	Showing the importance of the subject in everyday life	-	-	0.000
3	Encouraging students to explore alternative explanations or methods for	-0.667	0.583	-0.167
4	Incorporating "real-life" examples of your subject	0.333	-0.333	0.333
5	Incorporating 21st century skills into lesson plans and class activities	-0.917	1.167	1.333*
6	Assessing 21st century skills	-1.500	1.650	1.583
7	Teaching formal problem solving techniques	-0.917	1.167	0.917
8	Preparing students for the kinds of expectations they will encounter in a work setting	-1.200	1.500	1.417

* significance results from difference in means being outside of bootstrapping 95% C.I.

Discussion

The purpose of this program is to expose in-service teachers with a traditional license to the engineering design process through practical work experience. Once the program is complete, teachers can then decide whether or not they see value in incorporating more engineering design process concepts into the classroom, possibly making it part of their general teaching practices. Along with the engineering design process, the program also exposes teachers to the practical use of STEM concepts and 21st century skills and the importance in developing classroom practices that better engage students and potentially increase student learning.

The results show that several of the items in each of the analyses were significant. Table 1 showed that communicating solutions in written format was significant for the past participants when compared to current participants in regards to incorporating the engineering design process into classroom activities. However, eight of the ten items were trending towards the positive direction for past participants. Both items were significant for current participants, demonstrating the internship program changed the teachers' perceptions about the importance of using the engineering design process during classroom activities. Table 2 showed four significant items for past participants when compared to current participants in regards to incorporating STEM practices into classroom activities. However, 14 of the 15 items were trending towards the positive direction for past participants (a negative for lecture is a positive towards STEM practices). Five of the seven categories were significant for current participants, demonstrating the internship program changed the teachers' perceptions about the importance of using those STEM practices in the classroom. Table 3 shows that past participants think incorporating 21st century skills into classroom activities is significant when compared to current participants; as well as seven of the eight categories trending towards the positive direction of using STEM concepts for past participants.

Conclusion

From the results of this study, the researcher feels the internship program has the ability to significantly change teaching practices to increase the classroom use of the engineering design process and STEM learning concepts. Although not all of the survey questions were significant, many of the questions were significant while many others are trending towards the increased use of the engineering design process and STEM learning concepts. These trends could indicate that by participating in the internship program, and then having another year of classroom experience, it allows teachers to develop an appreciation for activities students may be expected to perform in a corporate work experience that require an engineering-related thought process and the need to more frequently engage in these types of activities in the classroom. The results of this study indicate that teacher internships are an effective professional development activity in regards to the engineering design process, STEM learning, and 21st century skills, and that more research is needed in this area.

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