122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #13210

Teachers in Industry: Teaching Transformed through Authentic Work Experience

Dr. Bradley Bowen, North Dakota State University

Bradley Bowen is an assistant professor at North Dakota State University. He has a duel appointment with the Teacher Education Department and the Department of Construction Management and Engineering. He has a B.S. in Civil Engineering from Virginia Tech and received a Master's of Civil Engineering and an Ed.D. in Technology Education from N.C. State University. He specializes in developing and integrating project-based activities into the K-12 classroom that incorporate engineering and STEM learning concepts as well as providing professional development for K-12 teachers.

Teachers in Industry:
Teaching Transformed through Authentic Work Experience
(WIP-5; Professional Development in STEM Learning)

Introduction

STEM learning is become more prevalent in today's educational system. This is because research is showing an increase in the demand for employees in STEM related fields.[14] One of the key aspects of STEM learning is the ability for students to learn and use formal problem solving methods while demonstrating competencies associated with STEM learning concepts and 21st century skills.[1,2,3,10] Incorporating these concepts into general classroom practices would provide students the opportunity to demonstrate these skills in an active learning environment. This concept is supported by the development of the Next Generation Science Standards and the Math Common Core Standards. Both of these sets of standards include learning outcomes based on the idea that developing a solution is as critical of a component of learning as arriving at the solution itself. Particularly evident in the Next Generation Science Standards, is the embedment of the engineering design process. These standards engage students in formal problem solving activities which increases the probability for effective solutions.[3] However, many teachers hesitate to include the engineering design process in their classroom because of their lack of understanding of engineering concepts. 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 design methods.[4,13,15] Teacher internships have proven to be a valuable experience for giving teachers knowledge about the engineering design process and STEM learning concepts.[4,5,6,7,8,9,15] 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.[4,6,7,8,9,15] This work in progress focuses on the following questions:

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

Program Description

Since 2011, the Teachers in Industry: K-12 Teacher Internship program has been placing K-12 classroom teachers into a 4-week summer industry work experience. This program is a collaboration between North Dakota State University, the Greater Fargo-Moorhead Economic Development Corporation, the South East Education Cooperative, regional industry businesses, and various North Dakota Regional Education Associations and Economic Development Associations. During the experience, the teachers work for a company that focuses on product design and development or engages in other engineering and problem-solving related processes. This internship provides traditionally licensed teachers an opportunity to experience how corporations are currently using the engineering design process and 21st century skills to solve technological problems. The teachers can then return to the classroom with the ability to make their course content more relevant and engaging for the students. The primary outcome of the program is for the teacher to gain an understanding about the importance of and the knowledge 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 two surveys to collect quantitative data about the teachers' classroom practices. The survey was 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] These surveys contained questions of a broader scope than the researcher wanted to use in the current study. In addition, the SWEPT survey questions primarily focus on science, therefore, the researcher in the current study adapted the questions to focus on the engineering design process. He also reorganized some of the questions into STEM concept and teaching categories. The researcher also used information from the Partnership for 21st Century Skills to develop the STEM concept and teaching categories.[2]

Two different methods were used to collect and analyze the data: 1) compare end of school year surveys of past cohorts versus current cohort, and 2) compare pre/post program surveys for the current cohort. The first component of the data analysis compared the effects of the program on previous cohorts of teachers compared to the current cohort of teachers. This data was collected by administering an end of school year survey to previous program participants and the upcoming cohort of teachers. The pre-program survey questions are attached in Appendix A. This survey also served as the pre-program survey for the current cohort. This was done to collect longitudinal data on current classroom practices of teachers that have previously participated in the program which could be compared to the current classroom practices for teachers about 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 administering a pre-program survey, which was the end of year survey previously mentioned, and a post-program survey. The post-program survey questions are attached in Appendix B. The pre-program survey captured data related to the teachers' current classroom practices in regards to the use of the engineering design process, STEM learning techniques, and current classroom practices. The post-program survey, given to the current cohort of teachers, captured data on how the internship program affected their perception and intended frequency of use of these concepts in the classroom during the upcoming school year. The questions on the post-survey were structured similar to the pre-survey. However, some of the individual questions regarding the engineering design process contained on the pre-survey were collapsed on the post-survey in order to present the options in more of a 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 activities they intended to use in the upcoming school year. To analyze the data collected from the surveys, a t-test was conducted to determine if there is a significant difference between the means between the two groups of data. The population for this project included 10 previous participants and 8 teachers in the current cohort. All of these subjects may not have responded to all the survey questions.

Results

Table 1 shows results for the statistical analysis comparing the past and current cohorts' perception of the importance of using various STEM learning concepts. Only the statistically significant items from the end of year survey are shown in the table. The first three items relate to general practices in STEM learning that the previous program participants perceive as being significantly more important than the current cohort about to enter the program. The last item is a comparison of the number of professional development hours spent on interdisciplinary collaboration during the last school year. The Likert scale used for all analyses are shown on the survey questions in the appendices.

Table 1.

Statistically significant results when comparing STEM learning concepts between cohorts

Question	Cohort	N	Mean	Std. Dev.	P-value*
When designing lessons, it is important for me to assess 21st century skills	Previous Current	8 10	3.63 3.00	0.183 0.211	0.045
How often do my students engage in investigating possible career opportunities in your subject	Previous Current	8 10	2.75 1.50	1.282 0.527	0.030[1]
I am confident about teaching the application of my subject to everyday life	Previous Current	8 10	3.38 2.90	0.518 0.316	0.029
During the last 12 months, how much PD have you participated in for interdisciplinary collaboration (hours)	Previous Current	8 10	51.63 2.80	47.848 6.546	0.023[1]

*Significant at $\alpha = .05$

[1]Did not pass for equality of variances; therefore Satterthwaite method was used

Tables 2-4 report the results of the statistical analysis when comparing the results of the pre- and post-program surveys for the current cohort of teacher participants. Table 2 reports the results for the statistical analysis comparing the current cohort's actual and intended use of various STEM teaching techniques. The researcher focused on these eight items because they are related to communication and reflection, which are critical components of STEM learning, and seem to be a recurring them in regards to one of the most important lessons learned from the work experience.

Table 2.

Statistical analysis comparing current cohort's current (pre) and intended (post) frequency of STEM teaching techniques

Question	Survey	N	Mean	Std. Dev.	P-value
Communicating solutions in written format	Pre Post	10 8	2.70 4.13	1.059 0.991	0.010*
Communicating solutions in oral format	Pre Post	10 8	2.80 3.88	1.033 0.991	0.040*
Communicating solutions by formal presentation	Pre Post	10 8	1.70 2.13	0.675 0.641	0.194
Reflecting in a notebook or journal	Pre Post	10 8	2.20 2.88	1.033 1.356	0.247
Developing a design portfolio	Pre Post	10 8	1.20 1.88	0.633 1.126	0.127
Critiquing their own work	Pre Post	10 8	2.80 3.63	1.229 1.061	0.153
Critiquing other students' work	Pre Post	10 8	2.10 3.63	1.101 0.916	0.006*
Reworking solutions based on self or peer evaluation	Pre Post	10 8	2.10 4.00	1.101 0.756	0.001*

*Significant at $\alpha = .05$

Table 3 reports the results for the statistical analysis comparing the current cohort's actual and intended use of various STEM classroom practices. In this table, the responses of each item combined two similar classroom practices, as demonstrated by the increased sample size. These items are separated on the survey, but combined for the purposes of the statistical analysis this was done because 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 activities they intended to use in the upcoming school year.

Table 3.

Statistical analysis comparing current cohort's current (pre) and intended (post) frequency of STEM classroom practices

Question	Survey	N	Mean	Std. Dev.	P-value
How often do you use (or plan to use) teacher-led lectures or discussion	Pre Post	20 16	3.80 3.63	1.322 1.088	0.673
How often do you use (or plan to use) student-led class discussions or presentations	Pre Post	20 16	2.00 2.81	0.918 1.276	0.033*
How often do you have (or plan to have) students work in pairs or small groups	Pre Post	20 15	4.25 4.20	0.911 0.775	0.865
How often do you have (or plan to have) students reflect in a journal or design a portfolio	Pre Post	20 16	1.70 2.38	0.979 1.310	0.086
How often do you have (or plan to have) students critique their own or other students' work	Pre Post	20 16	2.45 3.63	1.191 0.957	0.003*

*Significant at $\alpha = .05$

Table 4 reports the current versus intended frequency for the current cohort in regards to the use of the engineering design process. As previously mentioned, the steps of the engineering design process on the post-program survey were collapsed into one item, which were then compared to the average of all the steps listed on the pre-program survey. Thus permutation was used for this statistical analysis only given the large difference in samples sizes. As previously mentioned, 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 activities they intended to use in the upcoming school year.

Table 4.

Statistical analysis comparing current cohort's current (pre) and intended (post) frequency of using the Engineering Design Process

Question	Survey	N	Mean	Std. Dev.	P-value
Have students defining a problem when given probable scenarios	Pre Post	10 8	2.10 3.50	1.101 1.414	0.031*
Have students engage in various steps of the engineering design process	Pre Post	60 8	2.65 3.88	1.176 1.356	0.010*[1]

*Significant at $\alpha = .05$

[1]Permutation analysis was used for this item only due to the difference in samples sizes

Discussion

The results of this study show that several of the items in each of the analyses were significant. Table 1 contains the four significant items that are related to STEM concepts when comparing previous program participants with the current cohort. In regards to assessing 21st century skills, career exploration, and demonstrating relevance of the subject matter, previous participants of the program have a significantly higher perception of or use these concepts significantly more than the current cohort of teachers. The fourth item, the amount of professional development in interdisciplinary collaboration, was significantly higher for previous program participants. This could be an indicator that, by participating in the internship program, teachers understand the importance of interdisciplinary collaboration, and then seek out opportunities for professional development in this area.

Tables two, three, and four are comparing the data from pre- and post- program analysis. The results shown in Table 2 indicate there is a signifnace difference for four of the eight items in regards to the use of STEM teaching techniques. Communicating in both written and oral formats, as well as critiquing and reworking solutions, are intended to be used by the current cohort significantly more in the next school than they are in during the current school year. Teachers are also planning to have students engage significantly more often in the redesign phase of the engineering design process by having students rework solutions to problems based on self and peer evaluations. Table 3 results show the current program participants plan on significantly increasing the frequency of student-led discussions and presentations, and again, students critiquing work. The first item, regarding teacher-led lectures, was not significant, and showed a decrease in the mean value. This would still be an indicator that the teachers are placing greater value on STEM technique, since decreasing the amount of lecture is a shift towards a STEM learning philosophy.

In regards to the results shown in Table 4, current program participants plan to significantly increase the frequency of use in various steps of the engineering design process. The first item relates to students defining a problem, which is the first step of the engineering design process. The second item combined the steps of the design process from the pre-survey and compared this to a general statement about using the overall process in the post-survey. As previously mentioned, some of the individual questions regarding the engineering design process contained on the pre-survey were collapsed on the post-survey. The researcher felt that since the post-survey was collecting data on intended classroom practices, the teachers may not know exactly which steps of the engineering design process they would use, but could more accurately approximate the categories or types of activities they intended to use in the upcoming school year. When doing this, there was a significant increase in the frequently of how the teachers intend to use the engineering design process in the upcoming school year.

All of the teachers in this study have been past participants or are currently enrolled in the program. Many of these teachers already appreciate the need for a more in depth understanding of STEM learning techniques and the engineering design process, and maybe that is why they apply to the program in the first place. Therefore, many items on the survey may not show significant differences because both previous and current participants place a high value on the items included in this research study and may be currently engaging students in these activities in the classroom.

Conclusion

The purpose of this program is to expose in-service teachers to the engineering design process and STEM learning concepts through practical work experience. 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 increase content relevance to potentially increase student learning.

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. By participating in the program, teachers seem to recognize how industry is using the engineering design process and 21st century skills, and then understand the importance of increasing the frequency in which they use these concepts in the classroom. The significant items from Table 1 could be an indicator that, by participating in the internship program and then being able to practice these techniques in the classroom, teachers develop a greater appreciation for activities students may be expected to perform in a corporate work environment. To better prepare their students for the future workforce, they understand the need to engage students in these types of activities in the classroom more frequently. The results of this study indicate this particular teacher internship is an effective professional development activity in regards to the engineering design process, STEM learning, and 21st century skills, and more research is needed in this area. This study is a work in progress and therefore the sample size is relatively low. Therefore, this study is exploring the effectiveness of the teacher internship program and will continue to identify factors as the program continues and the number of participants increases. The researchers are satisfied with the outcomes of this work in progress study and plan to use more rigorous methods in the future to develop effective program components, assessment tools, and research techniques to document the effects of how this, and similar programs, impacts teaching practices.

References

1. Industry Initiatives for Science and Math Education (2013). http://iisme.org/
2. Partnership for 21st Century Skills. (2011). Professional Development: A 21st Century Skills Implementation Guide. http://www.p21.org/storage/documents/p21-stateimp_professional_development.pdf
3. Next Generation Science Standards (2013). http://www.nextgenscience.org/sites/ngss/files/Appendix%20I%20-%20Engineering%20Design%20in%20NGSS%20-%20FINAL_V2.pdf
4. Bowen, B. (2013). Teachers in Industry: Measuring the Impact of a K-12 Teacher Internship Program. Annual Proceedings of the American Society for Engineering Education, Atlanta, GA.
5. Silverstein, S. The Effects of Teacher Participation in a Scientific Work Experience Program on Student Attitudes and Achievement: A Collaborative Multi-site Study. http://scienceteacherprogram.org/SWEPTStudy/index.html3

6. Barrett, D. & Usselman, M. (2006). Assessing the Long Term Impacts of Scientific Work Experience Programs for Teachers. Annual Proceedings of the American Society for Engineering Education, Chicago, IL.
7. Barrett, D. & Usselman, M. (2005). Experience to Impact: A Comparison of Models of University-Based Summer Internships for High School Teachers. Annual Proceedings of the American Society for Engineering Education, Portland, OR.
8. Farrell, A. M. (March, 1992). What Teachers Can Learn from Industry Internships. *Educational Leadership*, p. 38-39.
9. Silverstein, S., Dubner, J., Miller, J., Glied, S. & Loike, J. (2009). Teachers' Participation in Research Programs Improves Their Students' Achievement in Science. *Science, Vol. 326*, p. 440-442.
10. Common Core State Standards Initiative (2013). http://www.corestandards.org/Math/Practice
11. Triangle Coalition for Science and Technology Education (2013). http://www.trianglecoalition.org/
12. STEM Education Coalition (2013). http://www.stemedcoalition.org/
13. The National Academies Press (2009). Engineering in K-12 Education: Understanding the Status and Improving the Prospects.
14. U.S. Department of Education (2015). http://www.ed.gov/stem
15. Bowen, B. (2014). K-12 Teacher Internships: Professional Development in the Engineering Design Process and STEM Learning. Annual Proceedings of the American Society for Engineering Education, Indianapolis, IN. (Poster Presentation).

Appendix A

End of School Year Survey (Also considered pre-survey for current cohort)

1. When designing lessons, it is important for you to:
   - Teach formal problem solving techniques
   - Show the importance of my subject in everyday life
   - Integrate my course curriculum with other subjects
   - Encourage students to explore alternative methods for solving problems
   - Incorporate "real-life" examples of my subject
   - Incorporate 21st century skills into lessons
   - Assess 21st century skills*
   - Prepare students for experiences they will encounter in a work setting

(Likert Scale choices: Strongly Disagree, Disagree, Agree, Strongly Agree)

2. How often do you use each of the following teaching methods?
   - Lecture
   - Teacher-led whole class discussions
   - Student-led whole class discussions
   - Student presentations
   - Students working individually
   - Students working in pairs
   - Students working in groups of 3-4
   - Students working in groups of 5 or more but less than whole class
   - Inquiry-based activities
   - Hands-on projects

(Likert Scale choices: Never, 1-2 days a month, 3-4 days a month, 1-3 days a week, Almost every day)

3. How often do your students engage in the following learning activities?
   - Defining a problem when given probable scenarios
   - Brainstorming
   - Exploring multiple solutions to a problem
   - Evaluating criteria or constraints to a problem
   - Designing models or prototypes
   - Building physical models or prototypes
   - Testing possible solutions to a problem
   - Communicating solutions to a problem in written format
   - Communicating solutions to a problem in oral format
   - Communicating solutions to a problem by formal presentation
   - Reflecting in a notebook or journal
   - Developing a design portfolio
   - Critiquing their own work

- Critiquing other students' work
- Reworking solutions based on self or peer evaluation
- Listening to guest speakers or taking a field trip
- Investigating possible career opportunities in your subject*

(Likert Scale choices: Never, 1-2 days a month, 3-4 days a month, 1-3 days a week, Almost every day)

4. How often do you engage in the following activities?
   - Consulting with industry representatives in my field
   - Researching subject content from professional sources (journal articles, websites, etc.)
   - Collaborating with teachers in my own subject
   - Collaborating with teachers in different subjects

(Likert Scale choices: Never, 1-2 days a month, 3-4 days a month, 1-3 days a week, Almost every day)

5. You are confident about the following aspects of your teaching:
   - Application of my subject to everyday life*
   - Advise students about job opportunities in my subject
   - Using inquiry-based instructional practices
   - Developing authentic assessment tools
   - Making the content relevant for my students
   - Designing hands-on activities
   - Incorporating 21st century skills into lessons
   - Assessing 21st century skills

(Likert Scale choices: Strongly Disagree, Disagree, Agree, Strongly Agree)

6. During the last 12 months, approximately how many hours have you participated in professional development on the following topics (not including a teacher internship):
   - 21st Century Skills
   - Engineering-related Design Processes
   - Interdisciplinary Collaboration*
   - Professional Learning Communities
   - Project-Based Learning
   - STEM Learning

* Statistically significant items discussed in the paper

Appendix B

Post Program Survey

1. During the internship program:
    - I gained a greater understanding of problem solving processes
    - I gained a greater understanding of 21st century skills
    - I gained a greater understanding of the applications of my subject area in everyday life
    - I became familiar with new materials that I can use in my teaching
    - I learned new ways to use existing materials in my subject area
    - I increased my knowledge of current issues in my field
    - I gained a greater appreciation of the difficulties some students encounter when learning
    - new material
    - I increased my knowledge of careers that use my subject area
    - I increased my knowledge of careers that use other subject areas
    - Prepare students for experiences they will encounter in a work setting

(Likert Scale choices: Strongly Disagree, Disagree, Agree, Strongly Agree)

2. The internship program increased my interest in:
    - Obtaining more professional development in my field
    - Integrating course curriculum with other subjects
    - Incorporate "real-life" examples of the subject I teach
    - Collaborating more with teachers in my own subject
    - Collaborating more with teachers in other subjects
    - Using more hands-on activities
    - Using a greater variety of instructional techniques in the classroom
    - Using more problem solving processes in the classroom
    - Using more 21st century skills in the classroom
    - Consulting with industry representatives in my field
    - Researching subject content from professional sources (journal articles, websites, etc.)

(Likert Scale choices: Strongly Disagree, Disagree, Agree, Strongly Agree)

3. In the upcoming school year, how often do you plan to use the following types of teaching methods?
    - Lecture
    - Teacher-led whole class discussions
    - Student-led whole class discussions*
    - Student presentations*
    - Students working individually
    - Students working in pairs
    - Students working in groups of 3-4
    - Students working in groups of 5 or more but less than whole class
    - Inquiry-based activities

- Hands-on projects

(Likert Scale choices: Never, 1-2 days a month, 3-4 days a month, 1-3 days a week, Almost every day)

4. In the upcoming school year, how often do you plan to use the following types of student learning activities?
    - Defining a problem when given probable scenarios*
    - Engaging in various steps of the engineering design process*
    - Communicating solutions in written format*
    - Communicating solutions in oral format*
    - Communicating solutions by formal presentation
    - Reflecting in a notebook or journal
    - Developing a design portfolio
    - Critiquing their own work
    - Critiquing other students' work*
    - Reworking solutions based on self or peer evaluation*
    - Listening to guest speakers or taking a field trip
    - Career awareness activities

(Likert Scale choices: Never, 1-2 days a month, 3-4 days a month, 1-3 days a week, Almost every day)

* Statistically significant items discussed in the paper