Educators in Industry: Using Teacher Externships as a Professional Development Models in STEM Education

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 School of Education 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 professional development in STEM and engineering education for K-12 educators.
Educators in Industry: Using Teacher Externships as a Professional Development Model in STEM Education
(Work in Progress)

Introduction

One of the critical aspects of STEM learning is the ability for students to apply formal problem solving methods and 21st century skills while demonstrating competencies of content standards.\textsuperscript{[1,2,3,10]} This is becoming an issue of national importance as research shows an increase in the demand for employees in STEM related fields.\textsuperscript{[14]} Incorporating authentic STEM learning concepts into a teacher’s general classroom practices would provide students the opportunity to demonstrate these skills in an active learning environment. This idea is becoming increasingly important as shown by the development of the Next Generation Science Standards (NGSS) and the Math Common Core State Standards (CCSS).\textsuperscript{[3,10]} 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 (EDP). These standards engage students in formal problem solving activities which increases the probability for effective solutions.\textsuperscript{[3]} However, many teachers hesitate to include the EDP 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 EDP or other formal problem solving design methods.\textsuperscript{[4,13,15]} Teacher externships have proven to be a valuable professional development (PD) experience for giving teachers knowledge about the EDP and STEM learning concepts.\textsuperscript{[4,5,6,7,8,9,15]} By seeing the EDP and 21st century skills in action, corporate work experiences can change a teacher’s perception of the need to incorporate more classroom activities that integrate the EDP and STEM learning concepts.\textsuperscript{[4,15,16]} This paper builds on research from other teacher externship programs by focusing on how the particular externship program included in this research project may increase a teacher’s use of the EDP and STEM learning concepts in the classroom.\textsuperscript{[4,6,7,8,9,15]} This work in progress focuses on the following questions:

1. How does the Educators in Industry program change teaching practices to increase the classroom use of STEM learning concepts?
2. How does the Educators in Industry program change teaching practices to increase the classroom use of the engineering design process?

Program Description

The Educators in Industry program places 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 ND Department of Commerce, and regional industry businesses. During the experience, the teacher works for a company that specializes in engineering design, product design, product development, continuing improvement processes, or engages in other engineering-related processes. This externship provides traditionally licensed teachers an opportunity to experience how corporations are currently using the EDP design process and 21st century skills to solve
technological challenges. The teachers can then return to the classroom with the ability to make their course content more relevant and engaging for the students. It also provides a more relevant opportunity for teachers to engage students in career awareness activities. The primary outcome of the program is for the teacher to gain an understanding about the importance of and the knowledge to incorporate the EDP, 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 (author).

Methodology

To collect data for the research project, the researcher used a mixed-methods approach. To collect quantitative data, two surveys were administered to collect information about the teachers' classroom practices. The surveys were adapted from the Scientific Work Experience for Teachers (SWEPT) Multisite Student Outcomes Study.\(^\text{[5]}\) The SWEPT Multisite Student Outcomes Study was conducted as part of an NSF Grant to research the impact of authentic research experiences for classroom teachers.\(^\text{[5]}\) The SWEPT survey questions primarily focus on science, therefore, the researcher in the current study adapted the questions to focus on engineering design and STEM learning concepts. Information from the Partnership for 21st Century Skills was used to develop the STEM learning categories.\(^\text{[2]}\) The researcher also collected qualitative data through individual and focus group interviews. This was used to better understand the results of the quantitative data and to gain a deeper understanding of how the program impacts teaching practices. These interviews occurred in spring of 2014, at the end of the school year following the 2013 summer externship experience. Six teachers participated in these interviews. These interviews were transcribed and analyzed for common themes.

Two different methods were used to collect and analyze the quantitative data: 1) compare end of school-year surveys of previous cohorts versus current cohort, and 2) compare pre/post program surveys for the current cohort. The first data analysis compared the effects of the program on teaching practices of previous cohorts compared to the current cohort. This was to determine if there was a significant difference in teaching practices of teachers that have participated in the program to those that have not yet participated in the program. This data was collected by administering an end of school-year survey to previous program participants and the upcoming cohort of teachers. The end of school-year survey questions are attached in Appendix A. This survey also served as the pre-program survey for the current cohort’s pre- and post-program analysis. The second data analysis measured 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 EDP and STEM learning techniques. The post-program survey, given to the current cohort of teachers, captured data on how the externship program affected their perception and intended frequency of use of these concepts in the classroom during 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 data sets. The population for this project included 26 participants from previous cohorts and 7 participants in the current cohort.
Quantitative Data Results

Table 1 shows results for the statistical analysis comparing the previous and current cohorts’ perceptions of the importance of using various STEM learning concepts. Table 2 shows the results of how the teachers engage in different PD opportunities related to the EDP and STEM learning. Only the statistically significant items from the end of year survey are shown in the table. A complete list of survey questions and the Likert scale used for all analyses are shown in the appendices.

Table 1.

*Statistically significant results when comparing STEM learning concepts between previous cohorts and current cohort

<table>
<thead>
<tr>
<th>Question</th>
<th>Cohort</th>
<th>N</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>When designing lessons, it is important for me to encourage students to explore alternative methods for solving problems</td>
<td>Previous</td>
<td>12</td>
<td>3.75</td>
<td>0.131</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>6</td>
<td>3.17</td>
<td>0.167</td>
<td></td>
</tr>
<tr>
<td>When designing lessons, it is important for me to incorporate 21st century skills into lessons</td>
<td>Previous</td>
<td>12</td>
<td>3.92</td>
<td>0.083</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>6</td>
<td>3.33</td>
<td>0.211</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at $\alpha = .05$

Table 2.

*Statistically significant results when comparing STEM and engineering-related PD between previous cohorts and current cohort

<table>
<thead>
<tr>
<th>Question</th>
<th>Cohort</th>
<th>N</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>During the last 12 months, approximately how many hours have you participated in engineering-related PD</td>
<td>Previous</td>
<td>11</td>
<td>2.64</td>
<td>0.678</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>6</td>
<td>0.33</td>
<td>0.333</td>
<td></td>
</tr>
<tr>
<td>During the last 12 months, approximately how many hours have you participated in STEM-learning PD</td>
<td>Previous</td>
<td>11</td>
<td>8.18</td>
<td>2.792</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>6</td>
<td>1.33</td>
<td>1.333</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at $\alpha = .05$

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

Table 3 reports the results of the pre- and post-program analysis of the current cohort’s actual versus intended frequency of use of the EDP. Only one item from this group of questions was significant.
Table 3.

Statistical analysis comparing current cohort’s current (pre) and intended (post) frequency of using various steps of the engineering design process

<table>
<thead>
<tr>
<th>Question</th>
<th>Survey</th>
<th>N</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have students rework solutions based on self or peer evaluation</td>
<td>Pre</td>
<td>6</td>
<td>2.50</td>
<td>0.342</td>
<td>0.048</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3</td>
<td>4.00</td>
<td>0.577</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at α = .05

Qualitative Data Results

The quantitative results did not produce many significant differences. Therefore, to gain a deeper understanding of the effects of the externship on the teachers’ classroom practices, the researcher conducted semi-structured interviews with six participants in the spring of 2014. These teachers had just participated in the externship during the summer of 2013. The following descriptions summarize the responses in regards to how the externship affected the teachers’ knowledge and perceptions about using the EDP and STEM learning concepts in the classroom.

**Engineering Design Process**

When commenting about their pre-program perceptions, most teachers acknowledged they did not know much about the EDP and have never used it as part of a formal classroom lesson. They had heard about the EDP during a variety of previously attended PD activities about the new NGSS and CCSS, but had never been exposed to the steps or how it is implemented. After the externship, all the teachers said they gained a tremendous amount of knowledge about the EDP. The teachers reported being overwhelmed at how much these corporations use variations of the EDP and 21st century skills on a daily basis. Two teachers with previous knowledge of the EDP said they recognized the need to use it in different contexts in the classroom. The most common theme was the benefit of seeing the EDP and 21st century skills in action. All the teachers commented that gaining knowledge of these concepts in a traditional PD workshop is not a substitute in an authentic context.

**STEM learning**

Before the externship, most teachers agreed that using a variety of STEM learning techniques in the classroom is important. These techniques include, but are not limited to; student-led discussions, small group work, solving real-world challenges, and incorporating 21st century skills, such as communication and collaboration. All of the teachers mentioned the externship experience redefined their definition of 21st century skills. They originally thought the term simply meant using computers or technology. The most common theme was how much more the teachers need to use 21st century skills in the classroom because these skills are essential to being successful in the workplace.

**Discussion**

The results of this study show that a few of the survey items were statistically significant. Table 1 contains the two significant items that are related to STEM concepts when comparing previous
program participants with the current cohort. In regards to encouraging students to explore alternative problem-solving methods, previous program participants report using this technique significantly more than the current cohort of teachers. Previous cohorts also report a significantly higher use of 21st century skills embedded into the classroom lessons. Table 2 contains two significant items that are related to the professional development hours when comparing previous program participants with the current cohort; the EDP and STEM learning. This could be an indicator of how the program impacts a teacher’s perception of the importance of engaging in PD in these areas. Once participating in the externship, teachers understand the importance of engaging students in these types of activities and therefore may seek out PD opportunities in these areas. Tables 3 shows the results from the pre- and post-program analysis. The results show one significant item, indicating teachers in the current cohort are planning to have students engage significantly more often in the reworking of solutions to problems based on self- or peer-evaluations. All of the teachers in this study have been previous participants or are currently enrolled in the Educators in Industry program. Many of these teachers already appreciate the need for a more in depth understanding of the EDP and STEM learning techniques, 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. However, the results of the interviews support the idea that the program increases the teachers’ understanding and desire to increase the frequency in which they use the EDP and STEM learning concepts in the classroom.

Conclusion

The purpose of the Educators in Industry program is to expose in-service teachers to the EDP and STEM learning concepts through practical work experience. By engaging teachers in authentic industry work experiences, teachers develop a deeper appreciation of the need to engage students in these activities. From the results of this study, the researcher feels the externship program has the ability to significantly change classroom teaching practices to increase the use of the EDP and STEM learning concepts. Although only a few survey items were significant, the interviews indicate a significant shift in the pedagogical thinking of how the teachers intend to engage students in the EDP and STEM learning techniques. By participating in the program, teachers seem to recognize how industry is using the EDP and 21st century skills, and then understand the importance of increasing the frequency in which they use these concepts in the classroom. The results of this study indicate the Educators in Industry program is an effective PD activity in regards to the EDP and STEM learning. The sample size for this study is relatively low, therefore this paper reports the preliminary effectiveness of the program and will continue to improve the research methods as the program expands and the number of participants increases. The researcher is satisfied with the outcomes of this work in progress study and plans to use more rigorous methods in the future to develop more effective program components, assessment tools, and research techniques to document how this externship, and similar programs, impacts teaching practices.
References

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 externship):
   - 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 externship program: (not analyzed in this paper)
   - 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 externship program increased my interest in: (not analyzed in this paper)
   - 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