Experiential Learning & Teaching in Higher Education

Volume 2 | Number 1 Article 10

6-1-2018

A STEM Experiential Learning Experience: A Five-Year Synthesis of Lessons Learned

Deborah L. McCarthy
Southeastern Louisiana University

Follow this and additional works at: https://nsuworks.nova.edu/elthe

Part of the Educational Methods Commons, and the Scholarship of Teaching and Learning Commons

Recommended Citation

McCarthy, Deborah L. (2018) "A STEM Experiential Learning Experience: A Five-Year Synthesis of Lessons Learned," *Experiential Learning & Teaching in Higher Education*: Vol. 2 : No. 1 , Article 10.
Available at: https://nsuworks.nova.edu/elthe/vol2/iss1/10

This Research Article is brought to you for free and open access by the Journals at NSUWorks. It has been accepted for inclusion in Experiential Learning & Teaching in Higher Education by an authorized editor of NSUWorks. For more information, please contact nsuworks@nova.edu.

A STEM Experiential Learning Experience: A Five-Year Synthesis of Lessons Learned

DEBORAH L. MCCARTHY
Southeastern Louisiana University

Abstract. From Fall 2012 to Fall 2016, 127 teacher candidates at a public university in southern Louisiana and elementary school students in grades four, five, six, and eight formed a Science, Technology, Engineering, and Mathematics (STEM) partnership to develop and implement science projects. The research questions of the accompanying study over the five years were: 1.Will mentoring a science project increase student understanding of best practices afforded by the scientific method? 2. What strategies improve the quality of a STEM experiential learning experience? A paired-samples t-test on teacher candidates' pre- and post-test scores showed a significant difference in mean scores, indicating an increase in understanding in students for each of the five years. Themes emerging from the qualitative data suggest that successful strategies include preparation, staying small, organization, communication, motivation, and acknowledgement. Coincidentally, these themes closely mirror the National Society for Experiential Education's (NSEE) "Eight Principles of Good Practice for All Experiential Learning Activities."

Introduction

In May 2012, the Louisiana Region VIII Science Fair director, who is also a colleague of mine in the Department of Biological Sciences, informed me that the Shell Company Foundation had awarded grant money to our university to support our STEM Educational Outreach Program. The idea was that teacher candidates enrolled in our university's capstone methods

© 2018 Southern Utah University Press & Design.
Correspondence should be sent to Deborah L. McCarthy, Southeastern Louisiana University, College of Education, Hammond, LA 70402.
Email: deborah.mccarthy@selu.edu
ELTHE: A Journal for Engaged Educators, Vol. 2, No. 1 (2018), pp. 57–73

courses would use a hands-on approach with junior high students to boost participation in science fairs. We therefore decided to establish a partnership with local schools so that our teacher candidates could mentor the junior high students through the development and implementation of their science projects.

In summer 2012, two schools accepted our invitation to participate. We met with principals and participating lead teachers to discuss logistics and put together a plan. Using this experience, and the quantitative and qualitative data collected from my teacher candidates over the last five years, I have learned valuable lessons regarding what criteria constitutes successful experiential learning. The objective of presenting a synthesis of this research is to offer educators strategies, identified by the participants themselves, that nurture STEM experiential learning. The findings appear to validate NSEE's "Eight Principles of Good Practice for All Experiential Learning Activities."

Theoretical Basis: The Impact of Real-World Experience

Real-world field experiences in science methods courses are recognized for promoting self-efficacy, positive self-perception in pre-service teachers as future science teachers, and the formation of informed images of scientists (Miele 2014; Smolleck & Mongan 2011; Thomas & Pedersen 2003). Moreover, the Next Generation Science Standards' (NGSS) Framework for K-12 Science Education has recommended that pre-service teachers learn to ". . . organize student groups; and guide students as they collect, represent, analyze, discuss data, argue from evidence, and draw conclusions" (National Research Council 2012, 258).

In 1916, John Dewey proposed that the processes of instruction result in proper thinking when they provide "an educative experience." The experience should be continuous, authentic, and interesting to the student, and it should generate an authentic problem that stimulates thought while the student becomes informed. The student should be able to observe in order to confront the problem, form solutions, and apply them to verify their validity (Dewey 2004, 157). Situated learning theorists Jean Lave and Etienne Wenger (1991) suggest that the "place of knowledge is within a community of practice," not in copying others' performances or learning through traditional instruction (100). Accordingly, experiential learning authority David Kolb (2015) writes, "Knowledge results from the combination of grasping and transforming experience" (51). Kolb also acknowledges the importance of reflection in experiential learning in his revised Kolb Learning Style Inventory. Identified by Kolb as The Reflecting Style, he writes that students need "the ability to connect experience and ideas through sustained reflection" (145).

In support of experiential learning, social learning theory has asserted, "In the social learning system, new patterns of behavior can be acquired through direct experience or by observing the behavior of others" (Bandura 1971, 3).

Since 1971, the National Society for Experiential Education (NSEE) has strongly advocated quality experiences outside of the classroom that promote the "demonstration of high-level cognitive skills." According to the society's publication, Strengthening Experiential Education: A New Era, "Experiential education provides a meaningful way for students to learn while pursuing educational goals important to their learning and to the greater society" (King 2013, 113). NSEE also advocates eight principles for a successful experiential learning activity: the intention of providing the learning experience, preparation for a truly authentic experience co-designed by those who will be affected, appropriate training, planning and preparation, an element of reflection, a continuous monitoring strategy precipitating improvement, a method of evaluation, and continuous acknowledgement of learning ending with a form of recognition for all participants (NSEE 2011).

How the Partnership Worked

Each fall semester, teacher candidates in their capstone methods course participated in a science fair partnership with a local school. After preparing in the methods classroom to develop science projects incorporating the scientific method, the teacher candidates formed mentor teams. They grouped the students and stocked folders with vocabulary sheets, graphic organizers, checklists, and suggestions for project ideas. For example, in 2016, twenty-one teacher candidates were assigned to a PreK-8 school. Three teams of seven teacher candidates each were formed, with each member of the three teams mentoring three students. Visits to the schools took place weekly for 90 minutes to guide 4th-, 5th-, 6th- or 8th-graders through selecting a problem, developing a question, forming a hypothesis and a procedure, collecting data, constructing a conclusion, designing a project board, and writing a report. A school fair was held, and winners at that school level then advanced to the regional fair. The teacher candidates completed a pre- and post-test, wrote weekly reflections, and enumerated benefits and challenges at the partnership's conclusion.

Methods: Fall 2012 to Fall 2016

During each semester, I used a mixed methods approach to investigate the following research questions: 1.Will mentoring a science project increase understanding of best practices afforded by the scientific method? 2. What strategies improve the quality of a STEM experiential learning experience?

Participants

Over five fall semesters, 127 teacher candidates participated in the partnership, 63 from the Curriculum and Instruction in the Elementary School methods course (grades 1-5) and 64 from the Upper Elementary Curriculum and Instruction course (grades 4-8). The participants included five white males, five African-American females, and one Asian female. The remaining participants (116) were white females.

Data Collection and Analysis Strategies

In summer 2012, the director of the Louisiana Region VIII Science Fair and I selected a pre- and post-test for teacher candidates and for students. We deliberately included BrainPOP's figures Tim and Moby the Robot because they were so recognizable to junior high students. Appropriately, the BrainPOP video (which can be viewed at http://www.brainpop.com) was also used to prepare the teacher candidates and students. What follows refers to the "Scientific Method Pre- and Post-Test: 24 Items" document in the Appendix. (To the original test, we added items 18-21 to cover terms important in experimentation. In fall 2012 and 2013, the teacher candidates completed the 24-item pre- and post-test. Item 20 was omitted from scores in fall 2012 and 2013 because no alternatives for this item were correct. The item was revised in 2014 to include a keyed alternative. By fall 2014, items 10 and 11 were removed to make the test more instructionally aligned with classroom preparation since "theory" and item 11 were not emphasized during preparation and process. Also, item 23 was omitted from those scores because it appeared to be repetitious regarding "replication," but it was reinstated in 2015-16. The final item was always considered ancillary because it is an opinion question.) I analyzed scores using a paired-samples t-test.

Following every weekly visit, one teacher candidate from each team submitted a reflection. The responsibility rotated within each team. The reflection included, "What we did," "What went well," "What could be changed," and "How the students reacted." At the conclusion of the partnership, teacher candidates completed a questionnaire on the benefits and challenges of the partnership. This questionnaire allowed the teacher candidates to summarize their opinions of the experience. When the partnership began in 2012, I did not ask for reflections; by fall 2013, I added the requirement, which became the groundwork for nurturing the partnership. I utilized a case study design to track the process of "a phenomenon of sort occurring in a bounded context" (Miles & Huberman 1999, 25), followed by a cross-case thematic analysis of the data. Coding was based on repetition of comments and terms, which were categorized, labeled, and tallied to determine a percentage for reporting. The lessons learned reflect the prominent themes that emerged.

Results: Fall 2012 to Fall 2016 Lessons Learned

By drawing on the experience and analyzing 99 weekly reflections submitted from Fall 2013 to 2016, along with 73 questionnaires completed from Fall 2012 to 2015, I was able to distinguish fundamental strategies that appear to nurture a STEM experiential learning experience. The lessons learned can be attributed to the comments of my teacher candidates. Coincidentally, after analyzing the data, I realized how closely the themes that emerged mirrored NSEE's "Eight Principles."

Qualitative Data: Fall 2013-2016 Weekly Reflections

Lesson 1: Prepare

To begin the partnership, I reviewed the consent form and explained its purpose: to mentor students through the development of a science project. The possible benefits I enumerated were a deeper understanding of the scientific method (in the students) and the experience of mentoring a group of students through a process requiring long-range planning (in the teacher candidates). A result of the experience could be the improved ability to instruct, which might transfer to student teaching.

An essential component of nurturing this partnership was teacher candidate preparation. Providing visuals such as the PowerPoint and BrainPop video, along with providing actual examples and sequencing activities, prompted the teacher candidates' prior knowledge of the scientific method. In addition, using real project boards displaying an example of an actual investigation involving conditions to prevent bread mold growth, and reviewing vocabulary with concrete items, proved effective. A teacher candidate commented in class that she wished her own teachers had explained terms such as independent variable and replication with such tangible examples. Twenty-nine weekly reflections documenting first or second visits supported the preparation's effectiveness. One hundred percent of these reflections described lessons that included the strategies used in preparation. One entry from 2015 read,

> On the first day, we began by introducing ourselves. . . . We then each held up a poster with the steps of the scientific method. We had the students attempt to put us in order. . . . Next, we went through a PowerPoint. . . and described an actual experiment with moldy bread. . . We had the students watch a BrainPop video . . . and reviewed the contents of their folders.

I provided to the teacher candidates engaging activities for the students, such games, videos, word searches, and crossword puzzles. However, I allowed the teacher candidates to use the resources whenever and however they thought would be most effective. This approach fostered creativity and adaptability in the teacher candidates. An excerpt from a 2013 reflection illustrates their resourcefulness: "The vocabulary sort [activity] was also a fun interactive way for the students to better understand the different terms used in the scientific method." Another wrote, "The students seemed to really enjoy the Jeopardy game. There were several students who got very excited and competitive."

Thirty-four percent of the teacher candidates mentioned the effectiveness of examples. One wrote, "I think going over the sample report showed the students the amount of time that goes into this project." In 2015 another stated, "I have also found that providing students with some guidance by providing examples greatly increases their motivation and understanding."

Similarly, in 2016, a teacher candidate wrote, "During the lesson, we were able to share an example of a science project, the Molded Bread experiment. This served as both a model and a visual for what they will need for their own projects."

Lesson 2: Start Small and Stay Small

As indicated in 69% of the 99 weekly reflections collected, it is beneficial to start small and stay small, both in student and partner teacher numbers. During the initial experience in 2012, my teacher candidates mentored over 320 fourth, fifth, and sixth graders. This involved 16 teachers. There were 33 teacher candidates, so the student-to-teacher candidate ratio was about 10 to 1. On a 2012 questionnaire (reflections were not required), a teacher candidate suggested, "Anything more than 5 students per mentor is too many. It does not allow students personal time to spend with a mentor to determine what to research or how to test." By the following semester, I reduced the number of elementary students to 84 to accommodate the 20 teacher candidates enrolled. That semester, a teacher candidate's reflection noted, "Working in groups . . . seemed to be the best way to get the students to understand the material best. Individual attention is very important in this classroom." Since the first partnership, the ratio has been no larger than 1 to 5. According to 28% of the reflections, having a more manageable ratio is crucial.

Another thing I learned is that it is desirable to involve partner teachers who wish to take part actively in the project. Agreement appears to affect the level of teacher involvement. Participation was mentioned in 40% of the reflections. In 2014, one teacher candidate wrote, "The teachers were not involved at all." Another reported in November 2014, two months after the partnership began, "There was no work done on the projects in science class. The classroom teacher walked around the room for the first time while we were there. . . ." Partner teacher involvement can affect classroom atmosphere. The following remarks show the extreme differences in the experience as related to partner teacher involvement. In 2016, a teacher candidate wrote, "[The teacher] was very helpful. She was eager to help her students, but also eager to answer any questions that we had and help as much as possible. The students were all very engaged and had [a] good work ethic." Conversely, a comment was, "I feel that the teachers need to be in their [sic] more to help control the students. . . . I feel that the students will take us more seriously and start to behave more."

Lesson 3: Motivate

Since 2013, the importance of motivation and its effects appeared in 68% of weekly reflections. Lack of student self-motivation was a significant complaint in Fall 2012 as it became evident that intrinsic motivation was not sufficient. Accordingly, in October 2013, some fourth-grade teams decided to implement their own incentive program. Mentor team members wrote, "Also, more of our students had their folders with work done because they were rewarded with candy" and "What went well was the fact that more students are working on their projects at home because they want to get more stickers on the checklist chart." Word spread quickly about such incentives. An eighth grade teacher candidate reflected, "The students' motivation needs to change. The group and I could try new motivation techniques in the classroom such as the ones that are being used by the groups at [another school]."

By 2014, the partner teachers and I agreed that an official incentive plan was needed, so we set up a system whereby students earned tickets for daily rewards, such as candy, chips, or school supplies with a reward of an iPod (2014-15) or Kindle Fire (2016) at the partnership's end. The incentive plan significantly raised the level of student self-motivation. Reflections from Fall 2014 documented, "The students (eighth-graders) are now finishing a lot of the required task. They enjoy receiving tickets and getting prizes" and "We let the students (fifth-graders) know that these tickets are hooked to their behavior that day. . . . The students were well-behaved during this experience. . . ."

During Fall 2015, a mentor of fourth-grade students reflected, "The incentive program is a great way to keep the students on task. It is also fun to see the students retrieve their prizes." A mentor of eighth-graders stated, "It was difficult to get an overall reaction but they were all excited about the prizes." In 2016, a mentor of fourth-graders wrote, "The use of positive reinforcement and incentives helped keep . . . students on track."

Only 25% of the reflections reported that behavior or work ethic did not appear to be affected by the rewards. For example, in 2016, a mentor of fourth-graders reflected, "When we distributed incentives, students were excited, but not quite excited enough to behave properly."

We also deduced that setting a class goal was unrealistic. The teacher candidates established individual goals for each student in their mentor group, and the benefits were direct. A 2014 team reflected, "Having [a] specific goal set for the students worked great. We are not completely sure if it was because we offered an incentive, gave them specific goals, or a combination of both."

Lesson 4: Organize

Organization was considered important in 46% of teacher candidates' weekly reflections. Thirty-five percent noted organizational issues mostly related to confusion in reserving the computer labs, lack of computers, not following the schedule, or lack of materials to complete student experiments. In 2014, a teacher candidate expressed frustration: "I also think that the teachers need to have the computer situation dealt with before arrival, because we waste precious time with the students when dealing with the computer issues." A 2016 comment reads, "The teacher has also not bought any supplies for students so I think this makes students feel as though this project is not important."

Graphic organizers and checklists were explicitly mentioned as organizational tools in 24% of the reflections. In 2013, one team questioned their fourth-grade group about "the progress of each kid to add to the checklist chart." In Fall 2014, a mentor of eighth-grade students reflected, "Using the checklist that the students get to keep allowed the students to visually see where they were in the process and helped them stay focused."

Supplying all student materials to partner teachers reduced some organizational issues. By Fall 2015, rather than emailing documents as attachments, I loaded them on a flash drive for the teachers. This saved time and redundant emails messages.

Lesson 5: Communicate

A reference to communication appeared in 19% of weekly reflections. To maintain contact with the school site, I frequently emailed participating school staff before visits concerning resources my teacher candidates would require and sent "gentle" reminders. In spite of increased communication, disorder sometimes occurred. In 2014, a teacher candidate wrote, "The administration scheduled two classes to be in the computer lab at the same time, and we ended up having to be the class to leave. This is poor organization and communication skills from the administration which could have been prevented."

I used weekly reflections, emails and class discussions to maximize communication with my teacher candidates. Reflections also provided opportunities to offer suggestions. I acted upon the "What could be changed" remarks as soon as possible. For example, in Fall 2013, three reflections noted the age appropriateness of the PowerPoint. A comment read, "The power point that we used was not appropriate for fourth graders, and many of them were confused after watching it." Consequently, I completely redesigned the PowerPoint to include visuals for vocabulary and each step in developing a science project. I used the familiar experience of finding mold on bread you were planning to toast for breakfast and wondering how it grew there. Apparently, my revisions were useful. In 2015, a teacher candidate typed, "Also, the PowerPoint was extremely helpful because it allowed the students to relate each step of the scientific method to an actual experiment."

Other teacher candidate recommendations were also implemented to improve the program. This suggestion came from a 2014 reflection: "I think next year instead of two classes, maybe just working with Ms. [X's] class would be better. . . ." Accordingly, in Fall 2015, we mentored only one class to reduce the student-to-teacher candidate mentor ratio. Another recommendation noted, "I think an awards ceremony would be nice to have after the judging is complete." So in Fall 2015, we held a small awards ceremony in the fourth-grade classroom after the school fair rather than having school personnel distribute ribbons after the partnership ended. In 2014, a teacher candidate commented, "Also, rewarding the students is just a great joy. I really like watching students who achieve get rewarded and get excited for their hard work."

Lesson 6: Acknowledge

Although the incentive program recognized student accomplishment on a weekly basis, after months of effort, we felt the students deserved formal acknowledgment and therefore arranged a school fair where that could happen. One hundred percent of the 17 weekly reflections documenting the school fair described a positive experience. On Fair Day, I provided snacks and drinks. These amenities were somewhat of a compensation for the teacher candidates, but the following remarks express what they really considered to be the prize. In 2015, a mentor of fourth-graders wrote, "I loved getting to see the students receive their ribbons. You could see on their faces how proud and excited they were to get the awards. . . . Students were cheering, clapping, and encouraging their fellow classmates." A mentor of eighth-grade students reflected, "But honestly, I would say just the fact that the students showed up and were excited about the work they put into their projects really stood out the most. For a majority of them you could tell they wanted to present their work. . . ." A 2016 comment also reflected the importance of acknowledgement: "The students were really excited to finally be able to present their projects, and we were just as excited to see their final product."

End of Partnership Questionnaire: Benefits and Challenges

A final questionnaire allowed the teacher candidates to summarize their opinions of the experience. Fifty-three percent of the 73 questionnaires mentioned the actual experience as a benefit. Forty-four percent referred to increased understanding of the scientific method. A 2012 comment touched upon both benefits: "The greatest benefit was the learning experience that was gained over the past nine weeks. Science is a subject that I have always struggled with. I am now more comfortable with teaching and working with the scientific method."

Some of the "What could be changed" comments in the weekly reflections were reiterated as challenges in the questionnaires. Student motivation and lack of partner teacher involvement contributing to organizational and communication issues were mentioned again. However, 26% voiced additional concerns regarding background knowledge. For instance, "Students had no prior knowledge of scientific method" and ". . . the students were on different learning levels."

End of Partnership Questionnaire: Benefits and Challenges

A final questionnaire allowed the teacher candidates to summarize their opinions of the experience. Fifty-three percent of the 73 questionnaires mentioned the actual experience as a benefit. Forty-four percent referred to increased understanding of the scientific method. A 2012 comment touched upon both benefits: "The greatest benefit was the learning experience that

was gained over the past nine weeks. Science is a subject that I have always struggled with. I am now more comfortable with teaching and working with the scientific method."

Some of the "What could be changed" comments in the weekly reflections were reiterated as challenges in the questionnaires. Student motivation and lack of partner teacher involvement contributing to organizational and communication issues were mentioned again. However, 26% voiced additional concerns regarding background knowledge. For instance, "Students had no prior knowledge of scientific method" and ". . . the students were on different learning levels."

Quantitative Data: Pre- and Post-test Results

Before any teacher candidate preparation began, I administered a pre-test, with a post-test following the partnership's conclusion. Every fall, analysis using paired-samples t-tests of teacher candidates' raw scores indicated a significant difference in mean pre-test scores compared to mean post-tests scores at the .05 level for all five years, as reported in Table 1 below. This result suggests that experiential learning had a powerful impact on the teacher candidates' understanding and ability to implement the scientific method.

Table 1: Statistical Analysis: Teacher Candidate Pre- and Post-test Results, Fall 2012 - Fall 2016

Fall 2012 Mean comparison of teacher candidates' pre-test and post-test results

Variable	*N*	*M*	*SD*	*CI 95%*	*t*	*df*	*p*
Pre-test	33	13.03	2.70	-5.31, -2.74	*-6.38	32	* .000
Post-test	33	17.06	2.78				

Fall 2013 Mean comparison of teacher candidates' pre-test and post-test results

Variable	*N*	*M*	*SD*	*CI 95%*	*t*	*df*	*p*
Pre-test	19	14.73	2.57	-6.13, -3.76	*-8.76	18	* .000
Post-test	19	19.68	1.29				

Fall 2014 Mean comparison of teacher candidates' pre-test and post-test results

Variable	*N*	*M*	*SD*	*CI 95%*	*t*	*df*	*p*
Pre-test	22	12.40	2.40	-4.03, -0.96	*-3.38	21	* .003

Post-test	22	14.90	2.26				

Fall 2015 Mean comparison of teacher candidates' pre-test and post-test results

Variable	*N*	*M*	*SD*	*CI 95%*	*t*	*df*	*p*
Pre-test	18	11.11	2.32	-8.22, -5.11	*-9.05	17	* .000
Post-test	18	17.77	2.43				

Fall 2016 Mean comparison of teacher candidates' pre-test and post-test results

Variable	*N*	*M*	*SD*	*CI 95%*	*t*	*df*	*p*
Pre-test	26	11.65	2.77	-6.44, -3.47	*-6.89	25	* .000
Post-test	26	16.61	2.77				

Table 2, below, provides a breakdown of raw scores and a comparison of the improvement in mean scores. It is difficult to infer if omissions and revisions had any effect on raw scores or mean scores. Perhaps if the same group of participants completed both the 24-item and 22-item pre- and post-tests at the partnership's end, inferences on effects could be made.

To discover any patterns among items, I compared responses from 85 pre- and post-tests collected from Fall 2013 to 2016. (Note that scores from 2012 could not be included in the analysis due to fire damage at the facility where we stored the documents.) The largest improvement from pre-test to post-test responses was in sequencing items 1-7 (see the Appendix).

Table 2: Analysis of Post-test Raw Scores and Percentage of Improvement in Mean Scores

FALL	HIGHEST SCORE	LOWEST SCORE	MEDIAN SCORE	IMPROVEMENT IN MEAN SCORES
2012	22/22	12/22	17/22	31%
2013	22/22	17/22	20/22	34%
2014	19/20	11/20	15/20	20%
2015	21/21	11/21	19/21	60%
2016	20/21	7/21	17/21	43%

Note: See omissions and revisions described in "Data Collection and Analysis Strategies" in the Appendix

Seventy-nine percent of teacher candidates' sequencing skills improved. The item "Is this a hypothesis that I can test? If digital cameras, Duracell batteries last longer than Energizer batteries" showed the most consistent results. Ninety-three percent of teacher candidates selected "yes" for both pre- and post-tests. Only 7% corrected their answers from "no" to "yes." The largest decline in accurate responses was for the item "If you were doing an experiment to find the temperature when green beans sprout the fastest, what would be the trials?" Thirty-eight percent of the teacher candidates changed correct answers to incorrect answers.

Discussion

The qualitative data collected over five fall semesters appear to suggest that preparation, staying small, organization, communication, motivation, and acknowledgement are fundamental strategies for providing a valued STEM experiential learning experience. The pre- and post-test results suggest that experiential learning afforded by the partnership did contribute to an increase in teacher candidates' understanding of the components of a robust investigation using the scientific method. What is also significant about the data collected is its relationship to NSEE's "Eight Principles of Good Practice for All Experiential Learning Activities." The parallel that the research showed was unintentional, which further strengthens the connection between what participants in experiential learning deem important and the eight principles themselves. Confirming NSEE's "Principle 1: Intention" was not an issue for the teacher candidates. As seniors in their capstone methods course, they were well aware of the benefits of experience over classroom instruction. In 2012, the initial year of the partnership, a teacher candidate bulleted this cautious comment in her questionnaire: "[This] has the potential to be a really awesome program for students, teachers and teacher candidates." By 2015, the following weekly reflection states with more confidence, "This partnership has been such a positive learning experience for everyone involved."

Additionally, I instructed the teacher candidates extensively before we went into the field, matching nicely with NSEE "Principle 2: Preparedness and Planning." Pre-program instruction also supports the theme "Lesson 4: Organize." From the teacher candidate's reflections and remarks, they appeared to feel prepared. In Fall 2015, one teacher candidate remarked in the questionnaire, "If I ever have a child or students who need to do a sci [science] fair – I know exactly what to do!" The teacher candidates also recognized the importance of schedules and checklists to track student progress in 24% of the reflections.

From the initial visit, meeting NSEE "Principle 3: Authenticity" was not in question. The teacher candidates discovered that progress is a process; motivation levels and cooperation vary in a real-world experience. In 2013, a teacher candidate identified authenticity as both a challenge and benefit. "We could not have asked/had a better real-world experience working with those students. However a challenge we faced during the experience were in fact real-world situations."

During the partnership, the theme "Lesson 3: Communicate" was also addressed. Communication among teacher candidates, partner teachers, and me was important in maintaining progress, organization, and planning for future changes. Often, after reading weekly reflections, listed as NSEE's "Principle 4," procedures and materials were adjusted as quickly as possible, which also allowed "Principle 6: Monitoring and Continuous Improvement" to take place. In addition, the use of a pre-test and post-test, along with the weekly reflections, provided the data advocated by "Principle 7: Assessment and Evaluation."

NSEE "Principle 8: Acknowledgment" occurred during the partnership and at its conclusion. This item also emerged from the study under the themes "Lesson 5: Motivate" and "Lesson 6: Acknowledge." Almost immediately after the teacher candidates initiated their own incentive plan in Fall 2013, student self-motivation improved greatly; therefore, by Fall 2014 weekly rewards became an integral part of the partnership. As mentioned above, beginning in 2012, a school fair was held; the fair's organization and awards were improved based on teacher candidates' reflections.

Implications

As supported by 40% of the comments related to the theme "Lesson 2: Start Small and Stay Small," it appears crucial that all facilitators have the opportunity to willingly participate in the experience. NSEE "Principle 1: Intention" advocates that all parties understand the significance of selecting experience over classroom instruction and the learning goals that will result. Perhaps if a brief session during a faculty meeting had been scheduled to introduce the learning outcomes of the partnership, the teachers would have felt more informed, engaged, and empowered.

With regard to "Principle 5: Orientation and Training," it appears that our program was lacking. The teacher candidates met their students and cooperating teachers on the first day of the partnership. There was no opportunity for introductions prior to that. Twenty-six percent of teacher candidates recognized as challenges the students' varied academic abilities, levels of understanding, and prior knowledge of the scientific method. Perhaps providing time for conversation, observation, and interaction would have improved the experience. An orientation period may have reduced some of the challenges noted by my teacher candidates.

In conclusion, this synthesis of findings could be useful to educators planning to implement a STEM program or any type of experiential learning experience. This study emphasizes the important role of self-reflection as a central component of the process and strongly supports the validity of NSEE's "Eight Principles of Good Practice for All Experiential Learning Activities." A Fall 2014 reflection is indicative of how my teacher candidates perceived the merits of a STEM experience and experiential learning as a teaching strategy:

This experience as a whole was beneficial to all of us . . . students because we were able to see a different side of the education spectrum. So much of the time we are just in the classroom with students and creating and following lesson plans. This was an opportunity to help prepare students to present their work on a much larger scale than just in front of their class, for a possible multitude of people, as well as present themselves in the process. It also gave us an opportunity to participate in something that is often expected of middle school students.

References

Bandura, Albert. 1971. *Social Learning Theory*. New York: General Learning Press.

BrainPOP.com. 1999-2018. "Scientific Method: The Mysteries of Life with Tim and Moby." Accessed June, 2012. http://www.brainpop.com/science/scientificinquiry/scientificmethod/.

Dewey, John. 2004. *Democracy and Education*. New York: Dover Publications.

King, Mary A. 2013. "Ensuring Quality in Experiential Education." In *Strengthening Experiential Education: A New Era*, edited by Garry Hesser, 103-163. Mt. Royal, NJ: National Society for Experiential Education.

Kolb, David. 2015. *Experiential Learning: Experience as the Source of Learning and Development*, 2nd ed. Upper Saddle River, NJ: Pearson Education.

Lave, Jean, and Etienne Wenger. 1990. *Situated Learning: Legitimate Peripheral Participation*. Cambridge, UK: Cambridge University Press.

Miele, Eleanor. 2014. "Using the Draw-a-Scientist Test for Inquiry and Evaluation." *Journal of College Science Teaching* 43, no. 4: 36-40. https://doi.org/10.1080/02635143.2018.1447455.

Miles, Matthew, and A. Micheal Huberman. 1999. *An Expanded Sourcebook Qualitative Data Analysis*. Thousand Oaks, CA: SAGE Publications.

National Research Council (NRC). 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: National Academies Press.

National Society for Experiential Education. 2011. "Eight Principles of Good Practice for All Experiential Learning Activities." Accessed Oct., 2015. http://www.nsee.org/8-principles.

Smolleck, Lori A., and Allison M. Mongan. 2011. "Changes in Preservice Teachers' Self-Efficacy: From Science Methods to Student Teaching." *Journal of Educational and Developmental Psychology* 1, no. 11: 133-145. DOI: 10.5539/jedp.v1n1p133.

Thomas, Julie A., and Jon E. Pedersen. 2003. "Reforming Elementary Science Teacher Preparation: What About Extant Teaching Beliefs?" *School Science & Mathematics* 103, no. 7: 319-330. https://doi.org/10.1111/j.1949-8594.2003.tb18209.