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A Case Study on Professional Development: Improving STEM Teaching in K-12 Education

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Abstract

STEM Outreach Center is a non-profit educational center in southern New Mexico that supports K-12 STEM teachers and students by providing professional development, after school programs, summer camps, and field visits. This center has been organizing the Summer Institute Professional Development (SIPD) for more than ten years. The purpose of this research is to understand the effect of SIPD on teachers' pedagogy to excite and engage students in STEM learning. This study contributes to the program evaluation by analyzing the experiences of teachers who participated in SIPD. This qualitative study uses the open-ended questionnaire as a method of data collection. The findings of this study show that teachers who attended the SIPD are eager to (i) integrate readings and arts in STEM teaching practices, (ii) improve their teaching pedagogies, and (iii) look for additional resources to support STEM teaching. Therefore, the authors recommend further research on how teachers transfer skills into their classrooms after attending SIPD.

Keywords

Case Study, Professional Development, Transforming STEM, Hands-On Activities, Experiential Learning

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A Case Study on Professional Development: Improving STEM Teaching in K-12 Education

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STEM Outreach Center is a non-profit educational center in southern New Mexico that supports K-12 STEM teachers and students by providing professional development, after school programs, summer camps, and field visits. This center has been organizing the Summer Institute Professional Development (SIPD) for more than ten years. The purpose of this research is to understand the effect of SIPD on teachers' pedagogy to excite and engage students in STEM learning. This study contributes to the program evaluation by analyzing the experiences of teachers who participated in SIPD. This qualitative study uses the open-ended questionnaire as a method of data collection. The findings of this study show that teachers who attended the SIPD are eager to (i) integrate readings and arts in STEM teaching practices, (ii) improve their teaching pedagogies, and (iii) look for additional resources to support STEM teaching. Therefore, the authors recommend further research on how teachers transfer skills into their classrooms after attending SIPD.
Keywords: Case Study, Professional Development, Transforming STEM, Hands-On Activities, Experiential Learning

Introduction

K-12 education has changed over the past decade due to different educational benchmarks by American Association for the Advancement of Science (1993), National Research Council (1996), No Child Left Behind (2002), Common Core State Standards Initiative (2010) and Next Generation Science Standard (2013), to name a few. These changes have contributed to pre-designed curricula, which prepare teachers and students for standardized tests and ignore the essence of teaching and learning (Bybee, 2013; Kubicek, 2005). The mission of Science, Technology, Engineering, and Mathematics (STEM) Outreach Center at New Mexico State University is to transform STEM education in the K-12 schools from teaching for the state standardized tests to student-centered approach (Glassett & Schrum, 2009; Rajbanshi, 2017). Professional development is a way to bring change in STEM education in K-12 schools. STEM Outreach Center has been providing teachers professional development for more than ten years.

Professional developments conducted by STEM Outreach Center is in the form of trainings, workshops, and seminars to introduce teachers to new knowledge and skills in the context of conceptual tools and allocation of roles as facilitators (Schlager & Fusco, 2003). Professional development helps to thrive at a high level of self-efficacy, and the result is seen in students' achievements (Ross et al., 2001; Watson, 2006). Professional development further helps teachers to polish qualities and enforce new strategies, effective practices, and techniques in teaching and learning.

STEM Outreach Center also supports teachers by (i) providing materials and resources to local elementary, middle, and high school teachers; (ii) coordinating field trips to nearby universities, museums, and historic sites; (iii) providing STEM-related hands-on activities; and (iv) providing partnerships and networking opportunities. STEM Outreach Center professional development incorporates new and innovative ideas into their curricula. STEM Outreach Center professional development also encourages teachers to develop and maintain a network for both veteran and new teachers to draw upon exploring STEM-related topics.

STEM Outreach Center creates a common space for teachers to share their feelings and frustrations as well as an opportunity to get benefits from both social and professional support. Professional development helps teachers to reflect on their teaching practices and acquire new knowledge. Professional development also allows teachers to come and work together and put themselves in the shoes of students by taking the role of a learner. Over the last decade, STEM Outreach Center has been providing professional development during summer as Summer Institute Professional Development (SIPD). The main goal of SIPD is to bring pedagogical change by providing hands-on curricula activities to teach STEM subjects in the classrooms and also to incorporate what the teachers learn in professional development as a part of their curriculum. Professional development contributes to a variety of activities such as "modeling, discussion, brainstorming of ideas, hands-on action, and just-in-time support" (Mouza, 2002, p. 285). With similar views, STEM Outreach Center supports learning in a collaborative form, by peer coaching, modeling, and doing workshops. According to Miller and Kastens (2017), the workshops provide a chance for teachers to connect with researchers and each other so that they can engage in a powerful deep content matter and teaching dialogues by reflecting on their teaching, reconceptualizing instruction, and modeling practice.

Literature Review

Professional development for teachers provides content as well as pedagogical knowledge that teachers can apply in the classrooms (Mouza, 2002). According to Henderson, McNeill, Gonzalez-Howard, Close, and Evans (2018), teachers need to learn new and more effective ways of teaching. Thus, professional development creates spaces in which teachers can share what they know and what they experience daily. Professional development forms learning communities outside their "comfort zone" and provides opportunities for teachers to learn from each other.

Professional Development: A Reflection on Student-Centered Pedagogy

Professional development is specially structured for teachers to connect with other teachers. In addition, when teachers get together, share their experiences and knowledge, they create a learning community with colleagues and experts outside their boundaries through professional development (Darling-Hammond & Ball, 1997; National Commission on Mathematics and Science Teaching for the 21st Century, 2000; Richmond, 1998; Schlager & Fusco, 2003; Web-Based Education Commission, 2000). In professional development, newcomers, pre-service, and in-service teachers gain access to new and innovative ways of incorporating STEM teaching by interacting with each other and getting familiarized with new technological tools.

Professional development, as experienced in this study focuses on shifting teachers' pedagogy from teacher-centered approach, which is the banking approach based on teachers providing facts and information to students (Freire, 1970, 1998), to student-centered pedagogy through hands-on pedagogy (Morales et al., 2019; Ozer et al., 2019). Student-centered pedagogy proposes that students should be investing their curiosity through inquiry and discovery, which drives their learning process (National Research Council, 1996). Therefore, based on student-centered pedagogy, learning should be hands-on and inquiry-driven (National Research Council, 1996; Wiburg et al., 2017). With this view, the focus of SIPD workshops is basically to provide teachers with hands-on and project-based curricula activities. Tekkumru-Kisa et al. (2017) stated that there had been a consensus that teachers' learning should be situated by artifacts of instructional practice. When teachers develop concepts through hands-on practice, they reflect on their experiences to incorporate similar practices in the classroom.

STEM Education

STEM education provides a curriculum that is built on four disciplines, namely science, technology, engineering, and mathematics. This curriculum blends these disciplines into a specific teaching approach through an interdisciplinary method that involves learning via real-life hands-on projects and prepares students to be competitive in the 21st-century workforce. In a STEM classroom that utilizes a student-centered pedagogy, students learn through hands-on and real-life experiences while the teacher has the role of a facilitator or a guide (Shernoff et al., 2017). Students are allowed to build their own learning by interacting with their peers.

STEM education as a curriculum choice and education policy has attracted the attention of researchers during the last two decades (Gonzalez & Kuenzi, 2012; Montgomery & Fernández-Cárdenas, 2018). According to Montgomery and Fernández-Cárdenas (2018), STEM education is often associated with national economic growth and human skills development. In this regard, STEM Outreach Center provides hands-on learning activities to the teachers, and the teachers become involved in those activities constructing knowledge through experiences and gathering content knowledge. Furthermore, STEM Outreach Center is also aware of integrating arts in STEM and thus puts effort in adding arts in all the activities such as workshops, afterschool programs, field trips, and summer camps.

Purpose of the Study

STEM Outreach Center provides professional developments to teachers from nearby districts. The purpose of providing professional developments is to change the attitude of teachers towards STEM, to improve STEM teaching through hands-on learning, and to empower teachers to stimulate student's STEM learning. The purpose of this study is also to shed light on the quality of the SIPD by:

- Explaining teachers' experiences on attending professional development
- Exploring changes in teachers' STEM teaching in the classroom

With the purpose stated above, the following research questions guided this study:

- What are teachers' experiences attending SIPD?
- How does SIPD change teachers' STEM teaching pedagogies?

Theoretical Framework

Experiential learning theory was built on Dewey's strong beliefs on how learning occurs through experiences and Piaget's focus on the cognitive development process. According to Dewey (1998), a teacher should know that the students' needs are at the center of the learning process. To Dewey (1998), there is an intimate and necessary relationship between the process of experience and learning. Similarly, Piaget (1970) stated that people build new schemas based on previous schemas. Learning occurs when people face a new situation. With that new situation, the existing schema changes with assimilation and adaptation of the new information. Based on Piaget (1970) and Vygotsky's (1978) social constructivist theory, learning occurs when learners construct new knowledge by interacting with peers in society. It is vital for teachers to value previous knowledge of students and connect learning to their experiences through social interactions, "without a connection to experience there is likely to be a gap between the subject matter to be learned and the interest in that subject matter" (Budd et al., 2015, p. 2).

Learning through experiences covers a significant part of the overall learning process. Coker, Heiser, Taylor, and Book (2017) emphasized that even if many benefits of experiential learning have been discovered, there is much more to investigate and utilize. Coker et al. (2017) also stated, "there is far less known about the relative benefits of depth, the amount of time a college student spends engaged with these high-impact practices, and breadth, the different types of experiences a student has while in college" (p. 5). Especially while teaching practical concepts, it is commonly agreed that experiential learning can be central to the teaching process (Yeo & Marquardt, 2015). According to Jose, Patrick, and Moseley (2017), experiential learning theory is based on the notion that learning occurs when learners use hands-on, task-oriented activities and relate previous knowledge in a contextual way to real-life examples, which is derived from constructivist learning theory.

In this study, we explored how experience can be used to modify previously accumulated knowledge and hence construct new concepts. Experiential learning theory proposes a different learning process to the traditional learning theories (Kolb & Kolb, 2009). David Kolb, the founder of the experiential learning theory, defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb, 1984, p. 41). Experiential learning is connected with the intellectual growth of an individual, which is linked with experience (Kolb & Kolb, 2009). Thus, experiential learning is a combination of experience, perception, cognition, and behavior (Kolb & Kolb, 2009).

As explained earlier, SIPD mainly focuses on teachers' experiences to construct new knowledge. Because of differences in experiences, constructed knowledge is never the same. Kolb and Kolb (2009) explained learning as a continuous process grounded in experience. Experiential learning provides a platform to add to existing knowledge and evoke creativity and personal development.

Research shows that professional development allows participants to be active learners (Parker et al., 2015). Teachers become learners who do activities, take initiatives, plan, and produce results. The results of the learning are "personal and self-constructed preparing for and leading to future experiences" (Marlow & McLain, 2011, p. 5), which makes teachers lead the classroom differently after attending professional development. According to Bruke (2013), the experiential approach allows participants to improve their teaching practices through self-directed growth and hands-on experience in professional development. SIPD creates a space to explore and empower teachers to stimulate students' STEM learning experiences through hands-on pedagogy and changes students' attitudes towards STEM. Therefore, experiential learning will be used as a theoretical framework to guide this study.

Research Methodology

The authors of this article include the former director and associate director of STEM outreach as well as the graduate students who worked in the center for at least two years in different capacities as graduate assistants and volunteers. STEM Outreach Center is a National Science Foundation (NSF) funded project and has used the questionnaire for internal evaluation of professional development. Experts such as the director and assistant director of the STEM Outreach Center reviewed and validated the questionnaire. Finally, the authors had the Institutional Review Board (IRB) approval before data collection and used pseudonyms to provide anonymity and for ethical purposes.

Description of Professional Development

In the process of conducting professional development, SIPD staff contacted school principals and provided detailed information to share with teachers. The theme of SIPD was *Turning STEM into STREAM: Incorporating Reading, Research, and Arts into STEM Practices.* This SIPD was a three-day workshop and each day teachers went through extensive sessions for six hours, including guest speakers' presentations who presented on the first and the last day to share their experience of incorporating reading and arts into STEM.

This professional development is designed to provide the participants with different ways of teaching STEM. For example, on the first day, the guest speaker presented on the theme of professional development. Along with that, there were different sessions of an hour on STEM topics. After these sessions, the participants went to their grade level sessions where they had engineering-design challenges. The engineering-design challenge continued the following day where the teachers were given problems to solve. With the materials provided, teachers had to engineer or design products to complete the challenges. For instance, kindergarten teachers worked on "egg drop challenge" while high-school teachers engaged with "trebuchet challenge." The teachers worked in groups where they shared their views and collaborated to solve the problems. Then, teachers presented what they engineered and shared how the given problem could be solved using their engineered design. Another example, on the final day, along with the guest speaker's presentation, facilitators provided mini sessions on different science, technology, and mathematics contents.

Methods of Data Collection

This study utilizes a questionnaire for the data collection process. A questionnaire is a data-collection method in which participants answer questions related to their behavior, attitudes, or beliefs. The questionnaires are common tools in research and education researchers have widely used questionnaires to collect descriptive and attitudinal data for social research (Fairbrother, 2014). The questionnaire contained demographic information and open-ended questions. This allowed us to get more in-depth information while not losing any demographic data.

Demographic questions allowed us to learn about our participants better. Some Open-ended questions included, "Please tell us the reasons for you to attend the SC2 Summer Institute Professional Development?," "What are some of the things that you learned from this SC2 Summer Institute Professional Development series?," and " How would you apply what you apply in this professional development in your classroom?" At the end of the three-day workshop, the participants were informed about the research, its purpose, and their participation to be voluntary before distributing the consent form and questionnaire. The participants were given ample time to think and answer the questionnaire. After the questionnaire was filled, both the consent form and questionnaire were collected from those participants who agreed to participate in the study.

Data Analysis

Description and Demographics of the Participants

One hundred and eighty teachers attended the SIPD in 2016. 169 teachers signed the consent forms to participate in the study, 148 were female and 21 were male. Also, 41 participants had 0 to 5 years of teaching experience, 39 had 6 to 10 years, 35 had 11 to 15 years, 28 had 16 to 20 years, and 26 had 21 or more years of teaching experience. The majority of the attendants were elementary teachers with 63 percent. Kindergarten teachers were 11 percent, middle-schools teachers consisted of 16 percent, and high-school teachers were 10 percent.

Selection of Themes

Coding is commonly used in qualitative research to analyze the data. Since the questionnaire had open ended questions, statements from the respondents were frequently visited to provide codes that referred to specific context, thus this was data-driven codes (DeCuir-Gunby et al., 2011). With the advance in technology, qualitative researchers relied on the tools such as MAXQDA and NVivo to analyze the data (Kuckartz & Rädiker, 2019; Saillard, 2011). As the STEM Outreach conducts research throughout the year, the authors had access to MAXQDA and used it to determine the themes for this study. This process was done separately by three authors individually using MAXQDA to determine the common codes. By connecting ideas and concepts, the codes were later grouped into themes. After individual analysis, all authors sat down in three different sections of two hours each to determine the final themes.

Results

The following themes emerged from the experiences of teachers, new pedagogical approaches for teaching STEM, availability, and accessibility of teaching resources, integrating reading and arts to engage students in STEM subjects, and exposure to hands-on activities.

Growth Opportunity for Improving STEM Teaching

Professional development was an opportunity for attendees to learn from each other. Novice teachers learned from experienced teachers and researchers. Teachers involved in activities that helped them to reflect on their own practices in the classrooms. In addition, they received feedback from their colleagues and experts. In the SIPD, teachers attended different sessions that focused on hands-on activities, and teachers deepened their understanding of content and pedagogies. For example, Ivana (pseudonym), who has more than 21 years of teaching experience in an elementary school stated, "this professional development is an opportunity to improve my everyday teaching skills" while answering the question focused on the benefits of the PD. She further added that after this professional development, she would be able to "challenge [her] students' creative thinking in science and mathematics." Her statement shows that after attending professional development, she anticipated that her teaching skills would improve.

Equally important, answering the same question, Cecilia mentioned that she sees SIPD as an opportunity for growth. Cecilia who teaches high-school kids Algebra I and II said, "I want to keep growing as a teacher." She believes teaching is an ongoing process and teachers always need opportunities to grow and learn new practices, learn from one another, and see what works and what to improve. As a result, this SIPD created an opportunity for teachers to both improve their teaching practices and grow as professional teachers. Stacey, another kindergarten teacher with more than 21 years of teaching experience, answering the same question highlighted that this SIPD was a great opportunity "to grow professionally and gain knowledge about STEM education." Teachers at southern New Mexico borderland have limited opportunities for STEM professional developments, and this SIPD created opportunities for the teachers to learn more about STEM education and improve their way of teaching.

SIPD allowed teachers to interact, share, collaborate, and learn from one another. This professional development allowed teachers to learn from experts as well as from other teachers. Experienced teachers have more to share while novice teachers got an opportunity to learn from experienced teachers. Teachers who have hands-on experiences in courses are the best authors of their work. Three teachers mentioned that they enjoyed learning from experienced teachers. In SIPD, teachers worked on different activities in groups and got the opportunity to learn from their groups and other groups as well.

Availability and Accessibility of Teaching Resources

The PD organizers used the materials available to almost all schools and allowed the attendees to sign up at the end of the PD to take some of the materials for their classrooms. Teachers in this professional development explored new ways of using and exploring educational resources to improve the lesson plans. Responding to the question of using the resources to support learning, Francine, an elementary teacher with more than 16 years of teaching experience said, "I have learned how to better structure my lessons regarding science. Knowing what resources are available helps." Teachers learned to design activities based on the resources they have in the classrooms to improve students' learning. Besides, teachers reflected on how they could use available resources in their classrooms to enhance their teaching practices. Sharing her experiences of using existing materials in the classroom, Martha a kindergarten teacher who attended this professional development for the first time stated, "I learned that you [I] can use many tools that you [I] already have in a classroom to create new and great lessons."

Furthermore, the professional development created a space for teachers to learn how to use materials that are available in their communities, outside of the schools. Through professional development, teachers shared how they teach different topics and find resources to support their activities. Teachers received information on the resources available to them in their communities that they could use in classrooms. The teachers also mentioned that the professional development opened their eyes on exploring resources that are outside of the classrooms. Claire, a kindergarten and elementary teacher who has attended this PD more than once said, "[I] gain a better understanding of resources in the community that I can use" in responding to the question of the STEM resources in the community. Being informed about other resources to use in learning activities motivates teachers to improve their teaching practices.

In addition to the materials available in the classrooms and communities, teachers were informed about the new materials they could buy and recommend schools to purchase for the classrooms. Teachers gathered information about what materials they could purchase that were relevant to the course content. The professional development informed teachers on exploring new materials for the classrooms and created an opportunity to get immediate feedback from experienced teachers on using those materials. Experienced teachers and keynote speakers shared materials that were beneficial for the classrooms. For example, Aline shared that she was "writing down suggested books from [the] keynote speaker[s] to be used along with required textbooks in classrooms." Through the data analysis, it became clear that the teachers took notes of the new materials and asked questions on using the new educational resources.

Integrate Reading and Arts to Engage Students in STEM Subjects

This professional development had activities that focused on integrating Reading and Arts into STEM teaching, which was the main theme of this PD. Teachers participated in the Reading and Arts and STEM activities and responded to the question of different strategies of incorporating Reading and Arts in STEM subjects. Berta, a second-grade teacher who teaches reading, science, and mathematics said that she would "have students build their own simple machines and have students write a story and then animate it using scratch." Expanding her learning activity to include a story is an example of connecting reading, writing, arts, and STEM.

Other teachers shared their strategies as well. Monique, a fourth-grade teacher said, "I thoroughly enjoyed the engineering design challenge and it was [an] eye-opening [moment] to see how easily state standards (including reading standards) can be addressed in a way that is engaging and allows students to think critically." The engineering challenge activity helped Monique to connect STEM and state reading standards.

Ana who teaches fourth grade and has been teaching for more than sixteen years mentioned that she "loved the grade level presentation" along with the engineering design challenge. She said, "I can't wait to add the engineering challenges to my science curriculum." The engineering challenge was one of the activities in this PD and most of the teachers liked this activity and wanted to include it or design similar activities for their classrooms.

Exposure to Hands-on Activities

Professional development created a way for the teachers to gain content and pedagogy that would excite and engage students in learning. Answering the question on how and what she learned would improve her teaching practice, Jennifer, an elementary teacher said,

> It's hands-on [that is] making the learning more than theoretical. It becomes applicable to our teaching. It's also inspiring! I can't wait to start planning to use these ideas in my classroom. One of the biggest reasons I love it is because the resources are available to us and it's nice to learn how to use them first.

Her statement implies that learning should be active and engage students. She was excited to implement the experience that she had during professional development through hands-on learning in the classroom. She also learned where to look for resources for her classroom. Thus, participants gained information on teaching through active participation and hands-on learning. Most teachers shared that this PD encouraged them to think new ways of incorporating hands-on activities in teaching STEM subjects.

A few teachers raised a concern that teaching for assessment limits hands-on activities. Cynthia, an elementary teacher exclaimed, "I want to make learning fun! Nowadays, we are concentrating on TEST[I]NG, TESTING, TESTING! We need to make learning fun again. I wanted new and innovative ideas that will bring back true learning." During the professional development, teachers participated in the hands-on activities that supported the New Mexico state standards. Therefore, sharing the experiences of using hands-on activities could provide innovative ideas for teaching STEM subjects.

Discussion

Findings of the Study

Based on the data analysis, this section discusses the research questions that were put forward at the beginning of the study. The first research question was on teachers' experiences, which states, "What are teachers' experiences attending SIPD?" Throughout the professional development, teachers performed different activities and experienced different ways of teaching other than just providing facts and letting students do worksheets. Not only teachers got information on teaching the content, but they also gained content knowledge from the experts. Teachers involved in activities that helped them to reflect on their own practices in the classrooms. In addition, they received feedback from their colleagues and experts. During professional development, teachers performed activities that "increase[d] their knowledge and skills and improve[d] their teaching practice, as well as contribute[d] to their personal, social, and emotional growth as teachers" (Desimone, 2009, p. 182).

The activities of the professional development concentrated on "helping teachers use particular curriculum materials (e.g., new textbooks, science kits, or curriculum replacements units) or describe[ing] teaching strategies (e.g., specific student questioning strategies)" (Garet et al., 2001, p. 923). Teachers in this professional development explored new ways of using the resources available in classrooms as well as the resources outside of the schools. They were also informed about new materials that they could buy and recommend schools to purchase for their classrooms. Teachers attended professional development with the assumption that they would learn how to better utilize available resources in the classrooms, "resources enabled them [teachers] to improve their instruction" (McCaughtry et al., 2006, p. 221). However, teachers received information on resources that are available to them in their communities to use in the classroom. Through professional development, teachers shared how they teach different topics and find resources to support their activities. Teachers generally converse "ideas and materials related to their work" (Borko, 2004, p. 7). As a result, this SIPD created an opportunity for teachers to both improve their teaching practices and grow as professional teachers. Furthermore, it is essential to note that professional development programs "can help teachers deepen their knowledge and transform their teaching" (Borko, 2004, p. 5). This research is consistent with other research findings, which show that professional development helps teachers to gain knowledge (Yoo, 2016; Whitworth & Chiu, 2015).

The second question that guided this research study was, "How does SIPD change teachers' STEM teaching pedagogies?" The data showed that teachers learned how to incorporate Reading and Arts into the STEM subjects. Integrating Arts and Reading in STEM is something that teachers were thrilled about and wanted to apply in their classrooms. Content area and reading should be closely supported to improve learning in all disciplines by making sense of the text (Shanahan & Shanahan, 2012). Therefore, it can be stated that after this professional development, teachers will be able to incorporate reading or literature within subjects, and the students will be able to understand the content. For students, science vocabulary is usually hard to understand. Incorporation of reading and arts can engage students and help them understand the content (Israel et al., 2013). Daugherty (2013) argued that arts significantly improves students' academic subjects along with reading. STEM focuses on providing solutions to problems, whereas arts help students to develop creativity and innovation. Arts education has been neglected in STEM (NRC, 2012) and is considered "special" to be pursued by privileged in K-12 education (Daugherty, 2013) and there is minimal support for the arts (Robelen, 2011) in teaching STEM subjects. To make students creative, arts should be integrated into STEM (Daugherty, 2013).

The teachers also experienced learning through hands-on activities, and this learning experience encouraged teachers to teach students using hands-on activities to learn the content. This professional development brought a change in teachers' teaching practice and improved pedagogical content knowledge. Furthermore, teachers added a small developmental step to boost teachers' confidence and identities as well as understanding content (Lee et al., 2014). One of the findings of Christensen, Knezek, and Tyler-Wood (2015) is that hands-on activities involve students in active learning that promote positive interest in STEM contents and careers. A similar result was shown by Rajbanshi (2017) who stated that learning through experience actively involves the student in learning, and students remember the science content. Hands-on activities allow students to concentrate on the learning process, understand the content, and create the end product. Such activities help students to develop interests in science and deepen content understanding (Rajbanshi & Brown, 2015). Facilitating hands-on activities stimulate interest in STEM programs (Colvin et al., 2012), which is also supported by this study. Thus, it can be stated that the professional development provided teachers with hands-on pedagogy that would not only engage students in STEM content but also help students stimulate interest in STEM programs. Therefore, this study supports prior research that PD "minimizes disparities in teaching and learning due to less experienced or knowledgeable teachers" (Seraphin et al., 2017, p. 1240).

It was surprising to the authors that the teachers had contradicting views on receiving the stipend for attending SIPD. On one hand, teachers pointed out that nobody needs to be paid for attending professional development because it is personal growth. On the other hand, teachers mentioned that a stipend is important for teachers to supplement their salaries for personal purposes such as childcare expenses for attending the SIPD or purchasing materials for students.

Even though this study could not be generalized to the STEM professional development in K-12, it provides findings that are essential to the STEM professional development in K-12, such as new pedagogical approaches for teaching STEM, availability and accessibility of teaching resources, integrating reading and arts to engage students in STEM subjects, and exposure to hands-on activities. STEM professional development follows different programs, including objectives and topics of interest. Professional development in STEM has differences, but they share the common goals of providing pedagogies and educational resources to improve STEM teaching practices.

Implications

The findings of this study are vital to in-service teachers, K-12 STEM PD organizers, higher education institutions, and researchers interested in STEM professional development in K-12. First, in-service teachers need an opportunity to learn from their colleagues what work in the classrooms and the best pedagogical approaches to improve their STEM teaching practices. This study showed that the in-service teachers who attended professional development increased their knowledge for teaching STEM subjects by incorporating the reading and art components and hands-on activities. In addition, they learned the new materials and how to explore and use efficiently the materials available in the classrooms. Thus, in-service teachers should participate in professional development to share their teaching experiences and learn from their colleagues.

Second, the organizers of the SIPD used experienced teachers to lead sessions. Teachers learned by doing. SIPD should continue to provide STEM-related professional development to support novice as well as experienced teachers to become innovative by empowering them in the field of STEM. Therefore, K-12 STEM PD organizers should involve teachers in leading the sessions and create an opportunity for novice teachers to learn from experienced teachers and know what is new in STEM teaching practices.

Third, higher education institutions should initiate outreach programs similar to STEM outreach to serve the communities and improve STEM teaching not only at the college level but in K-12 as well. Providing centers that provide professional development to K-12 teachers is an indicator of serving the communities and preparing K-12 students ready to pursue STEM majors at the college level and serve the communities.

Finally, future researchers interested in K-12 STEM professional development could use this study as a reference. The findings of this study highlight the importance of readings and arts in STEM subjects and ways of integrating hands-on activities in STEM. The authors recommend follow up studies to see how the transfer of skills done in SIPD improves teachers' teaching practices in the classrooms.

References

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* Oxford University Press.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Bruke, B. M. (2013). Experiential professional development: A model for meaningful and long-lasting change in the classrooms. *Journal of Experiential Education, 36*(3), 247-263.

Budd, J. M., Chu, C. M., Dali, K., & O'Brien, H. (2015, November). Making an impact through experiential learning. In *Proceedings of the 78th ASIS&T Annual Meeting: Information Science with Impact: Research in and for the Community* (p. 7). American Society for Information Science.

Bybee, R. W. (2013). The next generation of science standards and life sciences. *The Science Teacher, 80*(2), 25–23.

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Alignment of hands-on STEM engagement activities with positive STEM dispositions in secondary school students. *Journal of Science Education and Technology*, *24*(6), 898-909.

Coker, J. S., Heiser, E., Taylor, L., & Book, C. (2017). Impacts of experiential learning depth and breadth on student outcomes. *Journal of Experiential Education, 40*(1), 5-23.

Colvin, W., Lyden, S., & León de la Barra, B. A. (2012). Attracting girls to civil engineering through hands-on activities that reveal the communal goals and values of the profession. *Leadership and Management in Engineering*, *13*(1), 35-41.

Common Core State Standards Initiative. (2010). *Common Core State Standards for mathematics*. Retrieved from http://www.corestandards. org/assets/CCSSI_Math%20Standards.pdf

Darling-Hammond, L. & Ball, D. L. (1998). Teaching for high standard: What policy makers need to know and be able to do. *CPRE Research Reports.* Retrieved from http://repository.upenn.edu/cpre_researchreports/92

Daugherty, M. K. (2013). The prospect of an "A" in STEM education. *Journal of STEM Education: Innovations and Research*, *14*(2), 10-15.

DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2011). Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field Methods*, *23*(2), 136-155.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181-199.

Dewey, J. (1998). *Experience and education*. Kappa Delta Pi.

Fairbrother, G. P. (2014). Quantitative and qualitative approaches to comparative education. In M. Bray, R. B. Adamson, & M. Mason (Eds.), *Comparative education research: Approaches and methods* (2n ed., pp. 39-62). Springer International Publishing.

Freire, P. (1970). *Pedagogy of the oppressed* (M. B. Ramos, Trans.). Continuum.

Freire, P. (1998). *Teachers as cultural workers: Letters to those who dare teach* (D. Macedo, D. Koike, & A. Oliveira, Trans.). Westview Press.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Glassett, K., & Schrum, L. (2009). Teacher beliefs and student achievement in technology-rich classroom environments. *International Journal of Technology in Teaching and Learning, 5*(2), 138–153.

Gonzalez, H., & Kuenzi, J. (2012, August). Science, technology, engineering, and mathematics (STEM) education: A primer. *Congressional Research Service.* Retrieved June 3, 2018, from https://fas.org/sgp/crs/misc/R42642.pdf

Henderson, J. B., McNeill, K. L., González-Howard, M., Close, K., & Evans, M. (2018). Key challenges and future directions for educational research on scientific argumentation. *Journal of Research in Science Teaching, 55*(1), 5-18.

Israel, M., Maynard, K., & Williamson, P. (2013). Promoting literacy-embedded, authentic STEM instruction for students with disabilities and other struggling learners. *Teaching Exceptional Children, 45*(4), 18-25.

Jose, S., Patrick, P. G., & Moseley, C. (2017). Experiential learning theory: The importance of outdoor classrooms in environmental education. *International Journal of Science Education, Part B*, 1-16.

Kolb, A. Y., & Kolb, D. A. (2009). Experiential learning theory: A dynamic, holistic approach to management learning, education and development. In S. J. Armstrong & C. Fukami (Eds.), *The SAGE handbook of management learning, education and development* (pp. 42-68). Sage. DOI: 10.4135/9780857021038.n3

Kolb, D. (1984). *Experiential learning as the science of learning and development.* Prentice-Hall, Inc.

Kubicek, J. P. (2005). Inquiry-based learning, the nature of science, and computer technology: New possibilities in science education. *Canadian Journal of Learning and Technology, 31*(1). Retrieved on November 22, 2017 from https://www.cjlt.ca/index.php/cjlt/article/view/26506/19688

Kuckartz, U., & Rädiker, S. (2019). *Analyzing qualitative data with MAXQDA*. Springer International Publishing.

Lee, K. T., Chalmers, C., Chandra, V., Yeh, A., & Nason, R. A. (2014). Retooling Chinese primary school teachers to use technology creatively to promote innovation and problem solving skills in science classrooms. *Journal of Computers in Mathematics and Science Teaching*, *33*(2), 181-208.

Marlow, M. P., & McLain, B. (2011). Assessing the impacts of experiential learning on teacher classroom practice. *Research in Higher Education Journal*, *14*, 1-15.

McCaughtry, N., Martin, J., Kulinna, P. H., & Cothran, D. (2006). What makes teacher professional development work? The influence of instructional resources on change in physical education. *Journal of In-Service Education*, *32*(2), 221-235.

Miller, A. R., & Kastens, K. A. (2017). Investigating the impacts of targeted professional development around models and modeling on teachers' instructional practice and student learning. *Journal of Research in Science Teaching, 55*(5), 641-663.

Montgomery, C., & Fernández-Cárdenas, J. M. (2018) Teaching STEM education through dialogue and transformative learning: Global significance and local interactions in Mexico and the UK, *Journal of Education for Teaching, 44*(1), 2-13, DOI: 10.1080/02607476.2018.1422606

Morales, S., Trujillo, K., Mucundanyi, G., & Castillo, R. T. (2019). Math Snacks Early Algebra: Successes and challenges of a research design for computer-based games in Mathematics classrooms. In K. Graziano (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2185-2191). Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/207951/.

Mouza, C. (2002). Learning to teach with new technology: Implications for professional development. *Journal of Research on Computing in Education*, *35*(2), 272-289.

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before it's too late.* US Department of Education.

National Research Council. (1996). *National science education standards*. National Academies Press.

National Research Council (NRC). (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

No Child Left Behind (2002). Act of 2001. *Publ. L*, 107-110.

Ozer, M. A., Latorre, J., Rutledge, D., Mansour, T., & Altamirano, A. (2019). Digital native pre-service teachers' perceptions of using commercial and open source online applications in future praxis after completing technology integration course. *International Journal of Learning, Teaching and Educational Research*, *18*(2), 103-106.

Parker, C. E., Stylinski, C. D., Bonney, C. R., Schillaci, R., & McAuliffe, C. (2015). Examining the quality of technology implementation in STEM classrooms: Demonstration of an evaluative framework. *Journal of Research on Technology in Education*, *47*(2), 105-121.

Piaget, J. (1970). *Science of education and psychology of the child* (D. Coltman, Trans.). Orion Press. (Original work published 1969)

Rajbanshi, R. (2017). *A phenomenological study on middle-school science teachers' perspectives on utilization of technology in the science classroom and its effect on their pedagogy* [Doctoral dissertation, New Mexico State University].

Rajbanshi, R., & Brown, S. (2015). SEMAA—An afterschool program and its impact. *Advances in Education Sciences Volume 10*, 215-220.

Richmond, S. I. (1998). Report to the president on the use of technology to strengthen K-12 education in the United States. *American Secondary Education*, *26*(3), 28.

Robelen, E. W. (2011). STEAM: Experts make case for adding arts to STEM. *Education Week*, *31*(13), 8.

Ross, J., Hogaboam-Gray, A., & Hannay, L. (2001). Effects of teacher efficacy on computer skills and computer cognitions of Canadian students in grades K-3. *The Elementary School Journal, 102*(2), 141-156.

Saillard, E. K. (2011). Systematic versus interpretive analysis with two CAQDAS packages: NVivo and MAXQDA. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *12*(1). http://nbn-resolving.de/urn:nbn:de:0114-fqs1101345.

Schlager, M. S., & Fusco, J. (2003). Teacher professional development, technologies and community of practice: Are we putting the cart before the horse. *The Information Society, 19*, 203-220.

Seraphin, D. K., Harrison, G. M., Philippoff, J., Brandon, P. R., Nguyen, T. T. T., Lawton, B. E., & Vallin, L. M. (2017). Teaching aquatic science as inquiry through professional development: Teacher characteristics and student outcomes. *Journal of Research in*

Science Teaching, *54*(9), 1219-1245.
Shanahan, T., & Shanahan, C. (2012). What is disciplinary literacy and why does it matter? *Topics in Language Disorders*, *32*(1), 7-18.
Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education*, *4*(1), 13.
Tekkumru-Kisa, M., Stein, M. K., & Coker, R. (2017). Teachers' learning to facilitate high-level student thinking: Impact of a video-based professional development. *Journal of Research in Science Teaching, 55*(4), 479-502.
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, E. Souberman, & J. W. Wertsch, Trans.). Harvard University Press. (Original work ca. 1930-1934)
Watson, G. (2006). Technology professional development: Long-term effects on teacher self-efficacy. *Journal of Technology and Teacher Education, 14*(1), 151-165.
Web-Based Education Commission. (2000). *The power of the Internet for learning: Moving from promise to practice*. https://www2.ed.gov/offices/AC/WBEC/FinalReport/WBECReport.pdf
Whitworth, B., & Chiu, J. (2015). Professional development and teacher change: The missing leadership link. *Journal of Science Teacher Education*, *26*(2), 121-137. doi:10.1007/s10972-014-9411-2
Wiburg, K., Parra, J., Mucundanyi, G., Torres, R., & Latorre, J. (2017, March). Using emerging design models to develop Mathematics games. In P. Resta & S. Smith (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2043-2050). Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/177497/.
Yeo, R. K., & Marquardt, M. J. (2015). (Re) Interpreting action, learning, and experience: integrating action learning and experiential learning for HRD. *Human Resource Development Quarterly, 26*(1), 81-107.
Yoo, J. H. (2016). The effect of professional development on teacher efficacy and teachers' self-analysis of their efficacy change. *Journal of Teacher Education for Sustainability*, *18*(1), 84-94.

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