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Impact of STEM Professional Development Sessions on Chinese Pre-service Early Childhood Teachers

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Abstract

STEM only recently became part of the official Chinese public-school curriculum in 2017 and suggested to be included in the primary school curriculum in 2018. This study shares findings from 79 Chinese early childhood education undergraduate students participating in a variety of hands-on STEM activities over a two-week period. A follow-up question session was conducted with the translator as well. This training was offered outside of normal class times as a professional development. Data showed significant differences between the pre- and post- surveys along with strong relationships between main categories. Indications are that the sessions helped to promote the participant's interest, perception, self-efficacy in STEM, as well as, thoughts toward science teachers and classes. Findings most strongly indicated that the sessions aided understanding of STEM and that STEM could be fun in terms of both learning and teaching. Overall, it appeared that the professional development sessions were meaningful for the participants and highlighted STEM practices and concepts in a positive light.

Keywords: STEM, pre-service teachers, China, hands-on, professional development

INTRODUCTION

China holds the largest education (preschool through secondary) system in the world, servicing over 232 million students within more than 510 thousand schools, and employing more than 14.6 million teachers (National Bureau of Statistics of China 2018). To provide context, India employed nearly 8.7 million teachers (Ministry of Statistics and Programme Implementation 2017), and the United States employed approximately 3.6 million teachers (U.S. Department of Education 2019). Considering this scale, when changes in Chinese curriculum occur, the effects impact hundreds of millions. With this in mind, the Ministry of Education of the People's Republic of China (2017) issued the Compulsory Education Elementary Science Curriculum Standards, which suggested the inclusion of science, technology, engineering, and math (STEM) teaching practices beginning in primary school throughout the national curriculum. In effect, this addition to the standards has now opened the door for STEM education in Chinese public schools. The intention being to develop student scientific literacy at an earlier age more in line with international trends of STEM education (Pei, 2019). With such a recent policy change, it is understandable why there is such limited academic publication currently available in the area of Chinese STEM education. Some of the more affluent schools in larger city districts have already promoted varying levels of STEM activities, most often in the form of clubs or special classes.

However, as such a significant educational entity is now publicly acknowledging STEM education across the board, the need for research to identify Chinese student and Chinese educator needs in the area of STEM education is greater than ever before.

Despite China's progress in STEM, there are fewer researchers in the field of STEM than in other developed countries (Gao, 2013), and there are myriad difficulties in its research environment that impedes China's quest to be a global leader in science and technology (Han & Appelbaum, 2018). The findings of the study will help educators on how to successfully implement and integrate STEM in classrooms for improved learning outcomes of students, and will aid policymakers on how to bridge the workforce/gender gap in STEM occupations and education in China (Yang & Shen, 2020; Yang & Gao, 2019; Yiran, 2019). STEM education will play a pivotal role in realizing the "Chinese Dream" of becoming a world-class innovator by 2050 (Han & Appelbaum, 2018). An evaluation of the impact of STEM sessions in an Asian country like China is logically necessary (Wahono, Lin, & Chang, 2020). There is a need to conduct further studies in Asian countries to address the contextual challenges affecting STEM education in the region (Lee, Chai, & Hong , 2019).

Impact of STEM sessions

Moore et al. (2014) identified several key components for quality STEM education: the inclusion of math and science content, the inclusion of engineering design and/or redesign, the opportunity for students to learn from mistakes, emphasizing teamwork, activities that should be engaging and motivating, and approached from a student-centered style of teaching. Mooney and Laubach (2002) found success with curriculum spanning as briefly as two weeks improving student attitudes toward engineering, math, and science identified through pre and post surveys. Shahali et al. (2017) likewise found significant results when comparing their pre and post surveys where participants over five STEM activity sessions had increased positive interest in both STEM careers and STEM subjects. The intervention researched by Shahali et al. (2017) was aimed at connecting STEM concepts to real-world contexts through hands-on experiences. Researchers have identified that teachers should have knowledge of multiple STEM disciplines and should provide students with the opportunity to solve problems through hands-on experiences or learning by doing (Bybee 2013; Carscadden et al. 2019; Mooney & Laubach 2002; Honey et al. 2014; Nadelson et al. 2013). STEM is being integrated as long as at least two STEM categories are included in instruction (Bybee 2013; Honey et al. 2014). Honey et al. (2014) support that facilitators need to be explicit about STEM instruction and make connections to a real-world situation.

Further, they find that for STEM integration, pedagogy is essential, possibly even more so than content knowledge. This understanding and embrace of instruction being student-centered or student-led rather than teacher-centered or teacher-led are essential for STEM pedagogy (Bagiati & Evangelou 2015; Honey et al. 2014; Lesseig et al. 2016). Cotabish, et al. (2013) found that students would experience significant gains in science skills, concepts, and knowledge when paired with their teacher receiving professional development that would promote inquiry-based STEM practices.

Problem-based or project-based learning (PBL) is a hands-on student-centered experiential instruction method provided in the context of a realistic or real-world scenario or problem for the students to address (Euefueno 2019; Honey et al. 2014, Roberts et al. 2018). These projects or problems can be as brief as a single session or span for months, depending on scale and level of collaboration among the students (Euefueno 2019). Cobbs and Cranor-Buck (2011) hold that students overcoming STEM challenges learn to solve problems, communicate more effectively, and understand how to work together. Further, they find that this practice engages not only the student but also teachers, parents, and the curriculum.

Perceptions of STEM among undergraduates/pre-service teachers

Researchers over the last decade have pointed out the misconception of STEM, even among professionals in STEM-related areas (Keefe, 2010). Literature on students in STEM has identified STEM self-efficacy, motivation, and experience as influential factors of their perceptions of STEM (Roberts, et al., 2018). The misunderstanding of STEM among college students entering tertiary education and undergraduates already in STEM-related disciplines had led to a dearth of talent and increased attrition in STEM in many countries such as the USA and China (Dong, Wang, Yang, & Kurup, 2020; Chen & Weko, 2009; Lytle & Shin, 2020). Undergraduates experiences and perceptions of STEM has an effect on STEM retention and the overall persistence of students in STEM (Meaders, et al., 2020). Chen & Weko (2009) mentioned that college students favor non-STEM programs as their major in their initial years at college. A significant finding from their research revealed that only 28% of the students who enter STEM fields at college continue to obtain a bachelor's degree in STEM. Less than 40% of students pursuing STEM majors at college are able to complete a STEM degree due to negative experiences, loss of interest and confidence in STEM (Czajka & McConnell, 2016). In another study, middle-school students had a more positive perception of STEM than university pre-service teachers (Knezek, Christensen, & Tyler-Wood, 2011). When looking at the perceptions of preservice primary school teachers, it was found that these future teachers held strong beliefs about STEM and their intention to teach STEM in their classrooms (Kurup et al. 2019). The study also showed a deficit in the understanding of the preservice teachers in terms of making connections on how STEM relates to real-life scenarios as well as how to integrate science, technology, math, and engineering concepts into classroom instruction. McMullin and Reeve (2014) found that the most important factor in STEM program success is teacher perception and attitude towards STEM. The researchers identified that the teachers design and deliver higher quality STEM activities when they hold a more positive view of STEM. Researchers have found that teacher's perceptions of and attitudes towards STEM had a strong connection to their STEM practices (Margot & Ketler 2019; Park et al. 2017; Nadelson et al. 2013, Simoncini & Lansen, 2018; Srikoom et al. 2017). To yield a positive perception of STEM in students, instructors need to engage them in authentic STEM learning experiences (Roberts, et al., 2018). A first-generation undergraduate student who had the opportunity to participate in a STEM program had a new perception of engineering after the STEM activity (Martin, Stefl, Cain, & Pfirman, 2020). Pre-service and in-service teachers in Turkey who were not familiar with a STEM discipline had an improvement in their perception of STEM after training in STEM projects (Sungur & Marulcu, 2014).

STEM literacy and self-efficacy of pre-service teachers

Just like STEM, STEM literacy is difficult to conceptualize (Yip, 2020). Drawing from Zollman (2012) who defined STEM literacy as attaining scientific literacy, technology literacy, engineering literacy, and mathematical literacy, Yip (2020) opined that attaining literacy in the aforementioned four domains does not necessarily lead to STEM literacy. According to Yip, literacy in STEM is dependent on environmental, social, and cultural texts. And the dynamic nature of STEM, which keeps evolving, makes it difficult to assert that an individual has achieved STEM literacy. Effective instructional approaches that promote STEM literacy among students require an instructor to; (a) possess knowledge on the subject matter due to the abstract and complex nature of STEM, (b) possess skills, have experience, be creative in requisite pedagogies and technologies, (c) possess the understanding and skill of utilizing appropriate assessment practices, (d) have professional interactions with students during and beyond classroom sections, (d) and involving oneself and contributing to STEM disciplines through scholarly collaborations (Chang & Park, 2014). The researchers believe that the five approaches can aid teachers to provide a learning environment that stimulates students' interest and understanding in STEM. Roberts et al. (2018) and Yip (2020) also added that the introduction of significant pedagogical methodologies such as problem-based learning aids in enhancing the understanding and competence of pre-service teachers in STEM.

A key element to determine participant future participation in STEM is self-efficacy (Concannon & Barrow 2010; Brown et al. 2016). Self-efficacy is closely related to ones' beliefs, perceptions, and view of STEM usefulness when taken in the context of STEM (Brown et al. 2016). Self-efficacy was first presented by Bandura (1977), where he described the concept as essentially one's belief in one's ability to complete a given activity. Bandura holds there are four main sources for self-efficacy beliefs, of the four, mastery experience and vicarious experiences would be the most relevant to this study. Mastery experiences in that the participants actually perform given tasks in an effort to achieve a given objective and vicarious experiences as they observe the efforts of their classmates and have the opportunity to redesign their attempts. STEM self-efficacy is one of the influential factors affecting reluctance to pursue an educational path or career in STEM and STEM outcomes (Lytle & Shin, 2020). The researchers added that STEM self-efficacy is also a predictor the STEM interest and engagement, and the actual retention and recruitment of STEM students. Developing a sense of self-efficacy in STEM is vital for pre-service teachers in applying quality pedagogical approaches and addressing different needs to improve student learning, and enables them to persist in the midst of failure of an initial strategy (Kilpatrick & Fraser, 2019).

Professional development (PD) as a bridge for pre-service teachers' STEM competence

Professional development (PD) in STEM has the propensity to cultivate in pre-service and in-service teachers the 21st-century skills needed for an improvement in teaching practices which subsequently translate into better student outcomes (Brown, Alford, Rollins, Stillisano, & Waxman, 2013). Through STEM PD, teachers obtain opportunities to acquire novel teaching practices and content, foster student learning, and increase the professional knowledge of teachers (Estapa & Tank, 2017). Numerous studies that surveyed teachers' perceptions of STEM before and after PD indicates that teachers had an improvement in their understanding and integration of STEM after PD (Herro & Quigley, 2017; Herro, Hirsch, & Quigley, 2019). In one study, PD helped in successful STEM integration (Baker & Galanti, 2017). PD was also identified as one of the greatest factors to ensure successful STEM curriculum development and instructional implementation (Shernoff, Sinha, Bressler, & Ginsburg, 2017). Successful STEM PD enables pre-service teachers to be innovative during their own instruction, explore unknown concepts, and ensure sustenance in their learning of new materials over time (Baker- Doyle & Yoon, 2011). STEM PD also shapes the perspectives and practices of teachers regarding STEM, and also help them to narrow the achievement gap between groups of students (Li, Ernst, & Williams, 2015). During STEM PD, teachers benefit from collegial relationships/support and also from experienced teachers which challenges them to meet students' learning needs (Kilpatrick & Fraser, 2019). STEM PD is successful when teachers assume active role in the development process by implementing strategies, observing other teachers, and receiving feedback (Czajka & McConnell, 2016). PD in STEM must be active, coherent, reflective, collaborative, sustained, and focus on content knowledge to yield desired outcomes (Estapa & Tank, 2017).

STEM literacy in teaching and learning

STEM literacy is a unified theme in STEM literature owing to the fact that it is the ultimate outcome of STEM education. A positive impact of STEM sessions which is measured as STEM literacy is important because well-trained people in STEM disciplines are associated with economic growth and national security (National Research Council, 2007). Firstly, in integrating or implementing STEM content in teaching and learning, educators should focus on developing positive perceptions of STEM among learners to do away with the misconceptions of STEM (Czajka & McConnell, 2016; Keefe, 2010). This can be achieved by educators have sufficient content knowledge in STEM, recognizing attitudes and beliefs of learners, engaging learners at multiple levels (group and indvidual-based formats), forging authentic relationships with respect to classroom practices, allowing for reflection, and create a community where knowledge of STEM can be inquired and shared (Brenneman et al., 2019). When these are achieve, a positive perception of STEM is developed. Ultimately, learners begin to experience an increase interest towards STEM activities. Such learners place high value of STEM sessions, desire to have more STEM classes, and participate in hands-on STEM activities through a student-centered mode of teaching. According to Bandura (1977), students who develop interest towards a discipline and consistently engage in it develops mastery in the discipline. This mastery when complemented with vicarious experience (when learners watch their classmates perform a task and are given the opportunity to engage in personalized learning) will subsequently result in literacy towards one or more of the STEM disciplines. Thus, efficacious learners have positive perceptions of STEM, are interested in STEM activities, and demonstrate competence/literacy in STEM field(s). A successful STEM session results in STEM literacy of learners. Following this approach, a varied of STEM activities were designed to provide the learners with a conceptual understanding and knowledge of STEM, and a meaningful experience aimed at developing in them STEM skills (Baran, Bilici, Mesutoglu, & Ocak, The impact of an out of school STEM education program on students' attitudes toward STEM and STEM careers, 2019).

Theoretical framework

The integrated STEM education approach is a new framework that emerged from attempts to improve the students' interest and motivation for STEM (Kelley et al., 2021; Struyf et al., 2019; Thibaut, et al., 2018). This framework corresponds with the integrated STEM model by Sanders (2009). Sanders mentioned that "integrated STEM education includes approaches that explore teaching and learning between or among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (p. 21). Sanders' model has, however been criticized for not incorporating all the STEM disciplines. In this new framework adopted from Thibaut et al. (2018), a holistic approach is taken in integrating STEM education (i.e. there is an integration of science, technology, engineering, and mathematics disciplines). This has been underscored as the ideal integrated STEM education approach (Baran, Bilici, Mesutoglu, & Ocak, 2019). According to Thibaut et al. (2018), real-life problems are not fragmented in distinct disciplines as they are taught in classrooms but require skill sets that cut across several disciplines. Nadelson & Seifert (2017) defines integrated STEM as "the seamless amalgamation of content and concepts from multiple STEM disciplines. The integration takes place in ways such that knowledge and process of the specific STEM disciplines are considered simultaneously, without regard to the discipline, but rather in the context of a problem, project or task". The integrated STEM framework by Thibaut et al. (2018) encompasses five main instructional practices to foster STEM interest and motivation in learners; integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning, and cooperative learning. The five instructional practices are distinctive but interrelated principles.

All the five principles are supported by the social constructivist theory of learning, which suggests that students actively construct knowledge and that instead of individual experience, learning is shared. The first principle, integration of STEM content, is ensuring that learning goals, content, and practices from different STEM disciplines are explicitly assimilated. The second principle, problem-based learning, has to do with creating a learning environment that involves learners in authentic, ill-structured, open-ended, and real-life problems that increases the meaningfulness of content learned. Thirdly, inquiry-based learning indicates a learning environment that promotes student engagement relating to questioning, experiential learning, and hands-on activities that allow learners to develop new understandings and discover new concepts. The fourth principle, design-based learning, points to the use of open-ended, hands-on design problems that allow students to not only learn about engineering design practices and processes but also help deepen their understanding of disciplinary core ideas. The final principle, cooperative learning, entails giving students the opportunity to communicate and collaborate with one another to broaden their knowledge. Integrated STEM has been acknowledged as having a positive effect on students' cognitive and affective outcomes, student achievement, motivation to learn, and career interest (Struyf et al., 2019). Unlike the traditional "fragmented/segregated" STEM, integrated STEM education applies knowledge from all the STEM disciplines to solve complex and transdisciplinary problems. In one study, preservice teachers prepared for teaching using integrated STEM found it to be positive, rewarding and enjoyed participation (Gardner, 2017). This approach was followed meticulously in delivering educational content to the undergraduate students throughout the STEM sessions.

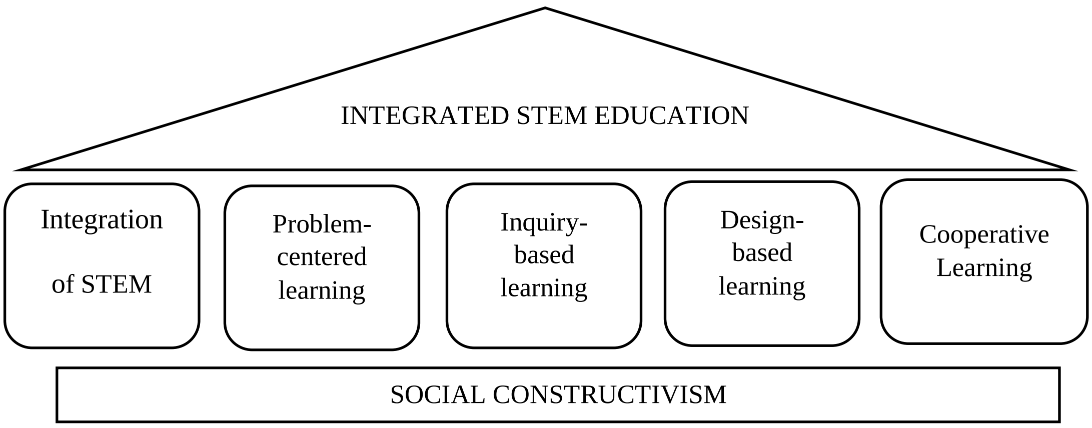

Figure 1. Theoretical framework for Integrated STEM education by Thibaut et al. (2018)

The present study

The main purpose of the study was to investigate the impact of a two-week STEM session on pre-service education teachers in China. Specifically, the study examined their; interests in STEM, the perceptions about STEM held, STEM self-efficacy, and their views towards STEM classrooms and teachers. Since STEM implementation is still at its infancy in China and there are limited literature on STEM in China in English, there is a critical need to examine how potential STEM teachers perceive STEM, their interests, and self-efficacy, and how a carefully integrated STEM session impacts their STEM beliefs and abilities. There is precedent for relatively brief STEM experiences having significant or meaningful impacts on their participants (Mooney & Laubach 2002; Nadelson et al. 2013; Roberts et al. 2018). Several tenants of Brenneman's, et al. (2019) four-year study were considered in the design of this study as their model found that there should be ongoing design, build content knowledge, recognize attitudes and beliefs, engage with various group and individual formats, be authentic in relationship to classroom practices, allow for reflection, create a community where STEM concepts can be shared. Four main categories were targeted within the surveys; the participant's interests in STEM, the perceptions about STEM held, STEM self-efficacy of the participant, and views toward science classes along with the potential positive influence of those affiliated teachers towards STEM (science classes/teachers). Additionally, items on the post-survey posed a variety of questions in terms of the perceived value of the sessions, desire for classes, whether teaching STEM would be fun and/or difficult, etc. The intent of this final set was to get an overview of perceptions to aid in the potential creation of future sessions and courses. Informal STEM learning experiences can promote greater interest and perception toward STEM (Kitchen et al. 2018; Roberts et al. 2018). A key component to foster these positive views towards STEM are through the use hands-on activities that have real-world contexts or applications. These informal learning experience provided students an opportunity to not only engage further in STEM activities.

The specific research questions of the study are;

1. How do learners rate their interest before and after STEM sessions?
2. What is the perception of learners before and after STEM sessions?
3. How do learners rate their self-efficacy before and after STEM sessions?
4. What are participant views towards STEM classrooms and teachers?

METHOD

Study design

The study is grounded on a mixed-method design. The explanatory design using sequential phases was used (Ponce & Pagán-Maldonado, 2015). In this way, more weighting was given to the quantitative phase of the study. Qualitative data was taken after measuring the attributes of the research problem to deepen the findings. The quasi-experimental design was adopted for the quantitative phase while a phenomenological design was used in the qualitative phase. A quasi-experimental design was used to investigate the impact of STEM sessions on preschool teachers in China. Quasi-experimental design is appropriate when there is an intact group and there is no need for randomization (Creswell, 2018). The kind of quasi-experimental design adopted for this study had no control group. With this type, which is often used by researchers, the researcher conducts a single pre-test observational measurement, implements an intervention, and conduct a post-test measurement (Harris, et al., 2004). In the current study, the intact group was Chinese pre-service teachers who were in their third year, majoring in education. No control group was assigned because the PD program was aimed at providing STEM education to all the preservice teachers. The researchers sought to examine how the STEM session had an impact on their dispositions (perceptions, interest, and self-efficacy) towards STEM activities. The purposive sampling was therefore used to recruit all the pre-service teachers.

Participants and sampling

Participants were a group of 79 (76 females and 3 males) Chinese undergraduate early childhood education majors in their third year of study. Education majors in this context would include preschool and primary ages. There are over 2.4 million preschool teachers in China, making up nearly 17% of the total preschool through secondary education teaching population (National Bureau of Statistics of China, 2018). This group of participants, and STEM tasks they were to be presented with, was relevant as children can identify themselves as problem solvers through problem-based engineering tasks in preschool settings (Blank & Lynch 2016). Similarly, other authors have found children aged as early as three to engage successfully with STEM tasks and concepts (Lange et al. 2019; Moomaw & Davis 2010). Additionally, the student (also an early childhood education major) who served as translator for the training period participated in a follow-up question session. The purposive sampling technique was used because all participants were involved in the training program. No attrition was recorded during the study. The data taken from the two specified sources help in triangulation.

Instrument

This study utilized a modified version of the questionnaire developed by Brown et al. (2016). The original survey contained 70 items. Their survey identified STEM self-efficacy and interest in as well as perceptions about STEM, looked at group work, and the potential for seeking a career in STEM. These later subcategories were removed, and only slight modification to some of the wording was done where deemed appropriate. The resulting construction was a pre-survey consisting of 41 items targeting 4 specific subcategories and a post-survey containing an additional 9 items unique to this study that examined general beliefs about STEM and the recent experiences. Several of the final subscales were of slightly different question construction and/or inclusion, however, resulted in higher reliability scores. Questions were on a 5-point Likert scale with 1 indicating "Strongly Disagree" up to 5 indicating "Strongly Agree". Table 1 below shows the reliability of the subscales when analysed using Cronbach's Alpha. DeVellis (2003) identified the levels of Cronbach's Alpha Coefficient as those below .60 as unacceptable, between .60 and .65 as undesirable, between .65 and .70 as minimally acceptable, between .70 and .80 as respectable, between .80 and .90 as very good, and above .90 as high enough to consider shortening the scale used. Three subscales were all found to hold a "very good" reliably falling within the .80 to .90 range and only the science classes/teachers fell in the "respectable range". The items were ultimately recoded into the subscales: interest in STEM, perceptions of STEM, STEM self-efficacy, and science class and teacher support. These would be used to compare pre- and post- test results to determine if the STEM sessions had any change in the views of the participants.

Drawing from extant literature, an interview protocol with a list of open-ended questions was designed by the first author. To ensure content validity and trustworthiness, the interview guide underwent peer debriefing and audit after it was reviewed by the second author. To explore further on the experiences gained during the STEM sessions, it was necessary to use a semi-structured interview guide to elicit voices on the activity over a two-week period.

Table 1. Comparison of Reliability Statistics Between Brown et al. (2016) and Current Study

Subscales	N (Valid Cases)	N (Items)	Cronbach's Alpha	N Mod (Items)	Cronbach's Alpha
Interests in STEM (Brown)	181	11	.86		
Interests in STEM (CS)	78	10	.86	11	.88
Perceptions about STEM (Brown)	181	7	.80		
Perceptions about STEM (CS)	79	7	.83		
STEM self-efficacy (Brown)	173	8	.84		
STEM self-efficacy (CS)	77	8	.76	11	.84
Science classes/teachers (CS)	79	4	.72		

As the additional 9 items in the post-survey were not intended to be a complete categorical variables or subscales, as such, only the means and frequencies are identified.

STEM sessions curriculum

Sessions ran over a two-week period and included three main hands-on student-centered STEM activities. Considering the size of the group, the class was divided into ten teams of eight students (one group being seven). Activities included a classic egg drop challenge where every member of the group had a selected role and worked to design and build the most cost effective, lightest, fastest, smallest, innovative, and/or best redesigned safe delivery system. The activity was framed in a more modern context of helping to design a safe package method for drone delivery and involved a redesign phase. Tower building which was the second activity also ran as a group. Teams used provided materials to design the tallest possible stable tower. As a twist, once time was called for the design phase, rather than let groups begin building their own tower, teams needed to exchange their designs with another team and follow the new plans they were given. The final activity was an individual activity where each would design and build a straw rocket and see which construction could fly the furthest. At the conclusion of each activity, discussion followed to highlight where each element of STEM could be seen. Discussion also stressed that it is not necessary to always see all four aspects of STEM in all STEM lessons. These activities were purposefully selected considering the size of the class, available materials, hands-on nature, potential experience of the participants, and relatability of the projects and problems presented.

Data collection

Surveys were distributed before sessions began in the first week and as the final concluding activity in the second week. The pre and post surveys were originally written in English and then translated into Chinese and checked a second time to confirm the Chinese translation. The surveys distributed to the students were presented entirely in Chinese. Students were informed about their participation in the surveys was voluntary. The only additional prompting was in the form of a bi-lingual projected slide asking students to please take a moment to complete the survey and there were no right or wrong answers, only the answer to the best of their ability. A follow-up interview session was conducted with the graduate student who served as a translator during the training session to supplement the quantitative data obtained from the pre-service teachers. The interview was conducted in English and approximately lasted between 20 to 30 minutes.

Ethical considerations

The study began after obtaining permission from the authors’ host university. Additionally, informed consent was obtained from participants after detailing the objective of the study to them. Participants were informed the study was purely voluntary and could withdraw at any stage of the study. During the qualitative phase of the study, the graduate student who was the respondent was assured of anonymity and no potential risk.

RESULTS AND DISCUSSION

Data Analysis

Of the 79 participants, data was usable at all stages of analysis from a minimum of 67 (85%) to a maximum of 75 (95%) unusable data was due to non-response of item(s) or an unidentifiable identification number to match the pre-test to the post-test. The surveys were coded and analysed using Statistical Package for the Social Sciences (SPSS) version 26. For the pre-test, items 5, 12, 15, 26, 30, 31, 33, and 36 were phrased in the negative and were recoded. Additionally, on the post-test, items 43 and 49 were also negatively termed and recoded for analysis. Qualitative data was transcribed verbatim using the Microsoft-Word tool. A content analysis strategy was used to select a list of responses relevant to the aim of the study.

Findings

The results are shared for the pre-post STEM subscales as well as for the additional post-test survey items.

Table 2. Pre/Post Means and Paired T-values for STEM Subscale Scores

Subscale	N	Mean Pre	Mean Post	Std. Dev.	T-value
Interest in STEM	68	3.36	3.62	.41	-5.28**
Perceptions about STEM	68	3.81	3.99	.47	-3.39*
STEM self-efficacy	68	3.47	3.77	.48	-5.16**
Science classes/teachers	67	3.80	4.07	.55	-3.98**

* $p < .005$ ** $p < .001$

Within table 2 pre- and post- means are shared for the survey subscales. All four subscales means increased significantly from the pre-test to post-test. Research question 1: how do learners rate their interest before and after STEM sessions?, (interest in STEM) increased from a mean of 3.36 to a post-mean of 3.62 ($t=-5.28$, $p<.001$). Research question 2: What is the perception of learners before and after STEM sessions?, (perceptions about STEM) increased from an already high mean of 3.81 to a post-mean of 3.99 ($t=-3.39$, $p<.005$). Research question 3: How do learners rate their self-efficacy before and after STEM sessions?, (STEM self-efficacy) saw an increase from a mean of 3.47 to a post-mean of 3.77

(t=-5.16, p<.001). Research question 4: What are the views towards STEM classrooms and teachers, the subscale of (science classes/teachers) rose from a mean of 3.80 to a post-mean of 4.07 (t=-3.98, p<.001). 3. 4.

Table 3. Correlations Among Pre/Post Subscales

	2	3	4	5	6	7	8
Pre-Interest in STEM (1)	.73**	.60**	.55**	.77**	.53**	.70**	.62**
Post-Interest in STEM (2)		.51**	.70**	.64**	.71**	.67**	.78**
Pre-Perceptions of STEM (3)			.69**	.71**	.48**	.65**	.43**
Post-Perceptions of STEM (4)				.53**	.64**	.62**	.70**
Pre-STEM Self-Efficacy (5)					.59**	.66**	.51**
Post-STEM Self-Efficacy (6)						.58**	.65**
Pre-Science Classes/Teachers (7)							.62**
Post-Science Classes/Teachers (8)							1

** p < .01

Table 3 displays the correlations between the pre- and post- subscales. All of the associations were found to be significant. The strongest associations were found between participant post-interest in STEM and post-science class/teachers (r=0.78, p <.01). Pre-interest in STEM was associated most with pre-STEM self-efficacy (r=0.77, p<.01). Pre-interest in STEM was also associated strongly with post-interest in STEM (r=0.73, p<.01). Pre-perceptions of STEM were associated with pre-STEM self-efficacy (r=0.71, p<.01). Likewise, Post-interest in STEM shared associations with post-STEM self-efficacy (r=0.71, p<.01). Though these were the strongest associations, again strong and significant associations were found among all subscales.

Table 4 shows that the STEM sessions were well received by the majority throughout. 85 percent of participants felt the sessions helped them have a better understanding of what STEM was only one student disagreed. Four of the participants felt they were more confused about what STEM was after the sessions. However, 52 of their peers found less confusion. 77 percent of the participants would be interested in taking a STEM class. 87 percent of participants felt learning more about STEM could be fun. 5 percent of students disagreed that the sessions were a good use of their time. 69 percent would recommend similar STEM classes to their friends. The greatest area concern was over the difficulty of teaching STEM with 31 percent holding a neutral view and 13 percent stating disagreement. However, 83 percent of participants showed levels of agreement toward teaching STEM could be fun.

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Table 4. Frequency, Percentages, and Means for Session Conclusion Questions

	Frequency Count of Responses					% D/SD	% N	% A/SA	Mean
	1	2	3	4	5				
These STEM sessions helped me to have a better understanding of what STEM is.	-	1	10	36	27	1	14	85	4.20
I am more confused as to what STEM is than I was before these sessions.*	-	4	19	28	24	5	25	69	3.97
If my school offered a STEM class I would want to take it.	1	2	14	40	18	4	19	77	3.96
I think learning more about STEM would be fun.	-	1	9	42	23	1	12	87	4.16
Attending these STEM sessions was a good use of my time.	-	4	18	37	16	5	24	71	3.85
I would recommend to my friends to attend STEM classes like these.	-	2	21	31	21	3	28	69	3.93
I enjoyed these STEM sessions.	-	-	16	39	20	0	21	79	4.05
I think STEM is too difficult to teach in a classroom.*	-	10	23	28	14	13	31	56	3.61
I think teaching STEM could be fun.	-	-	13	32	30	0	17	83	4.22

N = 74 on 1st question only N = 75 for the 2nd through 9th questions

*reverse coded (5 = strongly disagree)

Follow-up Interview

A series of follow-up questions was given to the graduate student who served as translator for all of the STEM sessions. Responses were given in English and did not require additional translation help to express themselves. A selection of their responses has been provided:

What are your thoughts on the STEM training you helped translate for?

"The stem course made me feel how interesting science is for the first time, and realized the importance of promoting the stem course in primary and secondary schools. This was my first contact with the stem course. In the process of participating in translation, I felt the creativity of the students."

How were those activities similar and/or different from activities you normally experience in class?

"Compared with other courses, these courses have strong hands-on operation, which can stimulate my interest in science and make me realize that science is not a distant ivory tower, but can be touched in daily life. The similarity is that they all talk about some scientific principles, but this course was not rigid explanations, but are perceived in life through activities."

Do you feel these sessions increased interest in STEM learning among your peers? Why or why not?

"Of course, these activities make people interested in understanding science and feel very interesting. They learn knowledge happily in fun."

Do you feel there were any communication problems for yourself or the participants? If so, how would you recommend to improve/overcome this?

"I don't quite understand some professional terms. I suggest you talk about the topic before each class."

Do you feel you and/or your classmates could replicate a similar activities for students after attending these sessions? Please explain why or why not.

"No, and systematic training is needed."

Discussion

The data showed that the STEM sessions were impactful in a positive way towards the views held toward STEM by the participants. The pre-test data provided a baseline for student beliefs toward STEM in general. Essentially, students seemed to only have a slightly above neutral interest towards STEM along with their self-efficacy with the topic in the beginning. Initially, the students approached agreement in the perception that STEM has meaning in their lives as well as the role science classes and teachers can play. When compared to the post-test results all areas saw a significant increase in levels of agreement as a whole. The STEM sessions clearly had an influence on their general views of the area. This was further supported by the additional nine post-test items which all approached or surpassed a level of agreement. The sessions were intended to make STEM accessible, understandable, and engaging for the university students. It was unknown how much if any STEM experience the students had prior and how the pedagogy of facilitator would be received. Class was conducted in a largely student-centered manner which is anecdotally understood to not be the typical method of class instruction. There appears to be an interest and place for further STEM opportunities in the university setting. A STEM out-of-school program designed to integrate STEM disciplines through hands-on problem-based activities implemented in a public research university was found to have enhanced the interest and understanding of students in STEM (Baran, Bilici, Mesutoglu, & Ocak, The impact of an out- of- school STEM education program on students' attitudes toward STEM and STEM careers, 2019). Similar to the findings of the current study, the researchers found significant differences between the pre and post-tests result regarding students' attitude toward social and personal implications of STEM and also their relationship to STEM. This implies that STEM education centers in universities can facilitate STEM integration by building undergraduate students' interest and confidence in and positive perceptions towards STEM disciplines (Carlisle & Weaver, 2018). STEM sessions in a form of PD is therefore a necessity for educators and administrators of universities to reduce the low-interest of the younger generation in STEM in Asia (Wahono, Lin, & Chang, 2020).

From the feedback provided by the session translator it was apparent that they felt the sessions were interesting and engaging for participants. The hands-on nature of the sessions made it possible for them to see connections between the subject matter and real life application. Discussion of the terms an concepts in advance with session translators might be advisable. The translator clearly felt that more PD was needed in order for students to be able to conduct these or similar activities with students of their own. According to Jing (2019), the biggest challenge to STEM education in China is to how to successfully integrate and systematize STEM courses with existing national courses. STEM PD sessions can help mitigate this reoccurring challenge by further exposing them model STEM teaching, as well as, help students develop interest and understanding in teaching STEM lessons in their own classrooms.

Limitations

As the researchers were not native Chinese speakers the language barrier was a potential area to address. In an attempt to mitigate this, bilingual translations were provided during visual presentations and a native speaking translator was on hand to translate much of the oral presentation and to help address individual questions. Surveys were also issued in the students' native language of Chinese. The researchers were also the facilitators of the STEM activities as well as the primary analysers of the data so there is potential for researcher bias in the interpretation. However, as this study used a quantitative survey as the chief means of data it should help to keep findings objective and the reader can also judge for themselves the strength and implications of the results through the provided analysis. There is always the concern with self-report data that responses could be disingenuous or simply an attempt to please the teacher/researcher. The researcher made no prompts beyond asking for the students to complete the survey and then simply began cleaning up materials not approaching the students while surveys were being completed at the conclusion. There was some attrition as several student identity numbers could not be matched pre- and post-, as well as, some surveys were submitted incomplete to varying degrees so those views could not be wholly shared.

Practical Implications

These STEM sessions were a first step in the process of developing a much larger STEM plan of action for the university. There appears to be a strong desire to participate in STEM not only from the students who joined these sessions but anecdotally from a number of other students, faculty, and administrators expressing their interest in further STEM education. With STEM only recently being adopted large-scale and recognized by the Ministry of Education of the People's Republic of China (2017) there is a clear need for educational universities to be prepared to support future educators. Plans are already underway for a semester-long course involving undergraduate and master's preschool and elementary education students led by the researcher and related colleagues. In addition to a variety of university student training, it is planned that the course will also include real-world application through partnerships with local elementary schools, kindergartens (preschools), and area museums for on-site activities. STEM professional development sessions are also being planned for teachers currently in the field. The success of these sessions has had an impact already, opening doors for larger initiatives that if continuing to be successful will only grow and expand. Funding will be sought to support future efforts allowing for greater access to materials for children, university students, faculty, and practicing teachers. There is a need for teachers to have the tools and understanding to meet the educational needs of their society.

CONCLUSION

Fostering interests, confidence, literacy, and positive perceptions of STEM among learners in this 21st century is the dream of many countries to tackle future challenges (Zhuang, Cheung, Lau, & Tang, 2019). Despite the considerable progress of China in STEM, there are contextual challenges such as limited academic publication, gender disparity, and negative experiences and/or perceptions that iteratively contribute to poor outcomes of and serves as potential threat to STEM in China (Yang & Shen, 2020; Yang & Gao, 2019). The study sought to assess baseline data on students' general perceptions of STEM and measure the impact of STEM sessions on their perceptions of STEM. Prior studies have established how effective STEM PD activities can increase learner interest, self-efficacy, literacy, and positive beliefs of STEM (Baker & Galanti, 2017; Baker- Doyle & Yoon, 2011; Estapa & Tank, 2017; Herro, Hirsch, & Quigley, 2019). Using students' pre-test and post-test data, the impact of a two-week STEM PD session was measured. Findings from the study revealed that the STEM sessions had a positive effect on the general STEM perceptions of participants. It was observed that there was a significant increase in all areas (interest, perceptions, and self-efficacy in STEM) from the initial data of participants. Based on the study results, an effective approach to integrating STEM in the classroom can foster student engagement and positive perceptions in STEM disciplines. The study provides an opportunity for an effective STEM implementation in the university setting. Theoretically, the current study is one of the few studies in English that provides an account on STEM sessions in the Chinese-context. Practically, the study offers educators and policymakers a background information of pre-service teachers' who would be potential teachers in STEM fields as China has rolled out STEM education in its national curriculum (Ministry of Education of the People's Republic of China, 2017). The STEM sessions also provided teachers a conceptual understanding on how to successfully integrate STEM in the classroom. The researchers believe that subsequent and frequent STEM sessions will advance the agenda of the New Engineering Education (NEE) initiative (implemented in 2017) which aims to produce STEM graduates that meet the international substantial equivalent standards (Zhuang, Cheung, Lau, & Tang, 2019).

SUGGESTIONS

It is recommended that future studies adopt sophisticated design such as a mixed-method to investigate if STEM sessions meet students' needs in a targeted discipline in STEM. Additionally, further studies can be carried on how the Chinese traditional culture affect the teaching and learning of STEM in schools.

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