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Analyzing Teachers' Technological Pedagogical And Content Knowledge

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ANALYZING TEACHERS' TECHNOLOGICAL PEDAGOGICAL

AND CONTENT KNOWLEDGE

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Dedication

To my beloved Danielle

ANALYZING TEACHERS' TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE

by

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Abstract

This qualitative study analyzes the ways a professional development course entitled Sol y Agua helped teachers to acquire technological, pedagogical, and content knowledge (TPACK) and to implement technology in their classroom. This study also analyzes the experiences teachers had in the workshop and the recommendations they had to improve the workshop. TPACK is a framework which denotes that teachers have a deep understanding of how to represent content using technology, and that the technology is used effectively to teach the content knowledge. Technology is integrated as a component of the teacher content knowledge and the teaching topic, and not as an accessory of it or a simple addition to it. For TPACK integration, it is required that teachers understand pedagogy, content, and technology, not in isolated but in combination with each other.

This study uses the case study approach in order to explain how teachers perceive the Sol y Agua workshop through in-depth interviews, focus group interactions, and a survey that was used to evaluate teachers' experiences with the TPACK framework. The findings will impact the micro-level by giving the creators of Sol y Agua evidence to improve the workshop, as well as impact the macro-level by exposing TPACK elements that can be incorporated in future teacher professional development courses infused with technology.

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Chapter 1: Introduction

Technological Pedagogical and Content Knowledge (TPACK) is a framework that includes instructional decisions made by teachers to integrate digital technologies as learning tools (Niess, 2011). Teachers in all disciplines require increased professional development in order to achieve technology integration in their classrooms. A great opportunity in order to accomplish this is to integrate a larger number of courses embedded with technological applications in teacher education programs and teacher professional development courses (TPDC), as well as to provide increased instruction for teachers with optimal strategies that model the use of learning technologies in instructional contexts.

TPDC and hands-on workshops often provide opportunities to help teachers improve their pedagogical strategies and content knowledge. These educational opportunities can be enhanced by giving participating teachers technological resources and by sharing new strategies to teach and engage students. Technological devices, applications, and software are excellent resources that can be used across content areas in order to motivate students to take an active role in their learning. However, teachers often do not have access to these types of resources in their everyday contexts or they do not have the time to take advantage of increased technical instructional support and enrichment. As such, teacher professional development learning opportunities offered by school districts and regional support organizations are often a primary option for teachers to learn new techniques and explore new software and technological applications. Professional development workshops and teacher preparation courses should also focus on developing twenty-first century skills for students, along with more hands-on activities that enhance the learning process in a real world context.

Pana & Escarlos (2017) consider that 21st century skills such as collaboration and team work, creativity and imagination, and critical thinking and problem-solving are necessary abilities for students to learn in order to be competent and competitive in local, regional, and global contexts. Additionally, Gilbert, Bloomquist & Czerniak (2016) state that professional development courses should provide teachers more tools and approaches to improve mathematics and computational thinking in students beginning in the early stages of their education.

The National Education Association (NEA) stresses the importance of preparing all students for the challenges of the 21st century. For this reason, the NEA is a founding member of the Partnership for 21st Century Skills, a national organization that encourages school districts to focus on developing these 21st century skills into their educational plans and programs. The focus of this organization is to develop elements for learning in all schools including emphasis on core subjects and learning skills, tools to develop skills, teaching and learning 21st century context and content, and using assessments that measure core subjects and related skills (NEA, 2019). Because of this, it is necessary that teachers in all schools are encouraged to facilitate students' preparation to be qualified for the competitive world they will live in by enhancing their own 21st century skills such as communication, collaboration, critical thinking, problem-solving, creativity, and innovation in order to be ready to face the challenges of globalization.

In an attempt to accomplish this approach with an emphasis on necessary skills for teachers and students, the Sol y Agua workshop provided a series of professional development modules that included the use of a digital game titled Sol y Agua. The game was specifically created for students in the West Texas area in order to study integrative science topics such as water sustainability, computational thinking, problem-solving, algorithms, and the use of

programming and data visualization software like python. The Sol y Agua digital game provides a good balance between science topics and technological applications. Therefore, this study is designed to identify how this workshop could be beneficial not only for teachers to acquire TPACK, but also for students to learn important 21st century skills that are emphasized in meaningful and engaging ways.

1.1 Statement of the Problem

Technology implementation in classrooms should help teachers engage students in appealing tasks to learn the evolution of school disciplines and how technology is related to their daily lives and contexts. There are research studies that recommend the inclusion of technology to improve the way students learn how to use such technology to solve problems (Clements & Sarama, 2016). In this regard, it is necessary for teachers to become aware of and acquainted with different types of technologies that can be implemented in their classes, and to have practical experiences utilizing various technologies to implement their curriculum. Despite the increased and rapid evolution of educational technology, its implementation in the classroom has not kept pace with its advancements. Factors such as teachers' lack of experience with technological applications in instructional contexts and the lack of technical support have decreased technology implementation in many classrooms.

Teaching with technology could result in benefits not only for teachers but also for students. For example, McKnight, O'Malley, Ruzic, Horsley, Franey & Bassett (2016) conducted a study to recognize some of the benefits of infusing technology into teaching. They found that technology improved access to resources leading to deeper and more appealing understanding of topics for students, and independence on selecting materials. The communication between teacher and students could be improved by selecting collaborative tasks such as virtual labs, chat

rooms, and discussion boards. Technology can also leverage time for teachers by decreasing their time spent in grading assignments, tests, and student writing. Technology can also expand the purpose and audience for students' work by sharing it not only with the class but with online communities. Finally, McKnight et al. (2016) mentions how technology could shift the traditional teacher role of lecturer and the student role as passive in the class. Using different types of materials and resources could decrease students' dependency on teachers.

In spite of the aforementioned benefits among others that could occur by the integration of technology in teaching, it is a difficult task for teachers who lack a sufficient level of TPACK to implement and design activities integrated with applied technology, mostly because they do not know how to use technological applications to fulfil their educational purposes.

For that reason, teacher development courses should provide participants with adequate TPACK so they can be more prepared to integrate technology into their classes. Teacher professional development courses with the integration of technology could help teachers to identify specific content and technological applications facilitating their integration into the classroom. In this way, teachers could instruct students with more engaging activities and materials by providing beneficial results not only for students but also for teachers by having more technological tools to support a student-centered approach and to achieve their curriculum goals.

1.2 Purpose of the Study

The purpose of this qualitative study is to analyze the TPACK impact that a teacher professional development series of modules (Sol y Agua workshop) provides to teachers in order to implement new technology in their classroom and to understand the perception of their participation in the workshop. To accomplish this objective, research questions will be utilized

and analyzed in order to better understand the role that the Sol y Agua workshop played in helping teachers gain knowledge in computational thinking, problem-solving, and skills such as creating algorithms, data visualization, and programming. This study included teacher surveys, focus groups, and personal interviews to understand the level of TPACK skills teachers received from the workshop and the subsequent integration of these skills into their classrooms.

1.3 Significance of the Study

Technology implementation studies are essential in order to develop a better understanding of how technology can be used to motivate and engage students in meaningful practices that allow them to more clearly understand their interactions with subject matter and its relation to their daily life experiences. Resnick (2006) mentions that using technology in the classroom has changed teaching and learning and promotes more chances to include problem based learning and hands-on activities.

However, there are some factors that limit the inclusion of technology in the classroom. Harrell & Bynum (2018) mention that factors such as poor infrastructure, inadequate technology, lack of sufficient technological tools, ineffective professional development courses, and low teacher self-efficacy and teachers' perceptions could affect any appropriate technology implementation in the classroom. TPDC should provide teachers with useful knowledge in order to implement technology with a purpose in their class, instead of being used only as an extension of the activities they are already doing in class. For example, using the computer to deliver information through a series of projected slides serves only as an extension of lecturing. In this sense, TPDC could provide teachers with knowledge about how to integrate technology as a tool to achieve their curriculum goals.

For that reason, it is important that this study investigate and understand how a professional development course, entitled the Sol y Agua workshop, assisted teachers to help them acquire TPACK and transform their lesson plans by embedding technology. The results from this study will add specific data to connect the implementation of a digital game and computational applications in the classroom context, to help students better understand aspects such as algorithms, data visualization, pH level measurements in water and soil, among other variables. By analyzing teachers' participation and perceptions from the Sol y Agua workshop, this study looks to provide solid evidence on how technology implementation is perceived by a group of teachers and how they could transform their pedagogy in order to include these skills in their classrooms. This evidence will be analyzed to better understand and anticipate the changes in teacher TPACK that the workshop provided to the teacher participants. The data will also be used to recognize how the digital game, Sol y Agua, and the computational applications used in the workshop can be integrated in different disciplines to promote meaningful learning for students in the West Texas area.

1.4 Research Questions

The research questions for this study are the following:

1. How can the Sol y Agua workshop promote teachers' acquisition of TPACK?
2. What do teachers think about technology intervention, including a digital game, in their practice?
3. What do the teachers note as positive and negative aspects, as well as challenges and rewards, within the professional development courses they receive in the workshop?

1.5 Assumptions, Limitations, and Delimitations

The assumptions of the study include that the Sol y Agua workshop be held during the Spring 2019 semester. Teacher participants were recruited with an open invitation directly from the Region XIX administrative department. Region XIX received the original invitation and the information about the workshop from the department of Computer Science at The University of Texas at El Paso. It was anticipated that the teachers who accepted the invitation to participate in the study answered the survey, focus group, and interview questions honestly. In order to assure that the teachers felt comfortable enough to answer freely, the study employed an informed consent form to explain the purpose of the study, the expectation of the participation in the study, and data management and confidentiality. The limitations of the study included that data was limited only to the teachers who agreed to participate in the study. The delimitations are that even though the workshop was originally created for middle school science teachers, it was offered to teachers from all disciplines and educational levels.

Summary

The integration of technology is desirable in all educational levels. For that reason, it is an important task to include more opportunities for teachers to integrate technology in teacher education programs and in TPDC, particularly because teachers often do not have the time and opportunity to learn new technologies, or they simply do not have access to technological resources in their daily practices. For the majority of teachers, TPDC are the only opportunity they have during the school year to learn new educational techniques and technologies to implement in their class to engage students and help them to develop skills that prepare them for their future. The 21st century skills required for students to be qualified and competitive in the

digital era include skills like communication, collaboration, computational thinking, problem-solving, and creativity.

In order to promote students' acquisition of 21st century skills, it is required that teachers use student-centered educational approaches, and include more educational technology to engage students to learn in more engaging and motivating ways. To achieve this, it could be beneficial to design more TPDC that include strategies for teachers to integrate TPACK in their classes.

Drawing from a qualitative perspective, the purpose of this study was to analyze the level of TPACK that teachers could acquire from the Sol y Agua workshop. It is the intent of this study to add to technology implementation literature by including details about how the application of technological programs like python, data visualization, and programming software, along with the integration of a digital game in the classroom, impacts teachers from different educational levels. A final purpose of this study is to better understand how a class can be transformed by including technology after teacher participation in a workshop specifically designed for the El Paso region.

Chapter 2: Literature Review

2.1 Teacher Professional Development Courses

Teacher professional development courses (TPDC) are training opportunities offered to teachers to help them with instructional techniques, new topics, or increase professional knowledge to apply to their classes. Alshehry (2018) states that the main objective of TPDC is to inspire teachers to move away from traditional lower-order thinking approaches including memorization, repetition, or recitation, and to move toward more active critical thinking approaches of teaching, such as small group discussions, think-pair-share, and discussing results from experiments. Sagar & Mehli (2013) affirm that TPDC should be able to motivate changes in teaching practices in order to achieve a transformation in the classroom. Unfortunately, TPDC are usually offered as a way to keep teachers focused on specific student achievement targets required by school districts or the goals tracked by administrators in individual schools. TPDC can be formal experiences like workshops, meetings, monitored activities, or informal experiences like educational videos, focused readings, and online training.

For example, Rashid (2018) asserts that teachers need permanent help to solve the problems they find in their daily experiences in the classroom. He discovered that even when professional development courses are not sufficient to fulfill that purpose, some teachers used social media and online communities to share their in-class experiences and to create reflections of their practices. This type of interaction allowed teachers the opportunity to provide a reflective dialogue of their activities in the classroom and to receive suggestions from other teachers. To this extent, teacher participation in online discussions with other teachers in their network could

help them to reflect and to benefit from their experiences in order to solve problems and implement different techniques in their classrooms.

At the present time, in order to be relevant and effective, TPDC should focus on the integration of technology in order to engage and to provide benefits to students. For this reason, having TPDC infused with technology can be useful for teachers to design and create engaging and motivational activities with tasks emphasizing the effective use of technology (George & Sanders, 2017; Lee, Longhurst & Campbell, 2017). Additionally, it is necessary that the activities including technology are specifically designed to enhance the topic and learning objectives. To reach the correct implementation of technology, it is necessary that TPDC reflect teachers' needs and provide them with practices that promote a change in their practices to provide a solution to their specific requirements (Rogers & Twidle, 2013).

An example of this approach is presented by Campbell, Longhurst, Wang, Hsu & Coster (2015) in a study of a professional development (PD) course. In this PD course, information and communication technologies (ICT) were used to improve teacher and students' learning by supporting technological literacies. The PD course was aligned with state standards, pedagogical content, and cognitive ICT tools for a science class. The findings of this study demonstrate that ICT integration helps teachers and students to visualize technology differently, to have more tools to promote engagement, and to provide students with novelty methods to communicate and collaborate in class.

However, most often, the school curriculum does not adequately reflect the actual instructional needs teachers have in their daily practice. Additionally, it is also important that teachers balance the knowledge they have with the demands they receive in their TPDC in order to understand how they will implement technology within their classroom instruction. Therefore,

it is crucial to have courses and support for teachers not only once a year but regularly throughout each academic year so that teachers can increase their knowledge and instructional implementation abilities (Lee, Longhurst & Campbell, 2017). In a study conducted by Unger & Tracey (2013), it was reported that secondary science teachers found it useful to have an online technology professional development intervention every five weeks during the academic year. The teachers adopted the use of Google applications such Google Drive and Google Docs to communicate and share with all school staff by posting all the materials in a common folder shared by all personnel. The intervention was perceived as valuable for teachers because they felt supported by their school and had technical support. It is important that teachers receive technical support in their technology implementation in the class so that they can develop instructional materials that can be easily found and shared with other teachers.

Zhang, Parker, Koehler & Eberhardt (2015) conducted a study in which a list of science topics that teachers needed to improve within their content knowledge was identified. The data analysis also unveiled some areas that teachers needed to strengthen such as pedagogical content knowledge, instructional strategies, curriculum, and assessment. For example, it was found that science teachers needed to improve upon some topics like life science, physical science, and earth science, as well as refine the way they taught these topics in order to better align to their students' needs and the curricular changes. The study also found that one of the greatest challenges for teachers, even for the experienced ones, was teaching with an emphasis on inquiry. The study proposed that professional development programs could be a significant support to teachers in order to strengthen their inquiry-based teaching approaches according to the actual needs in the curriculum.

It should be noted that teachers have different educational needs depending upon their specific circumstances, the grade they teach, their subject area, and the type of students they have in class. Khan & Khan Afridi (2017) state that many TPDC are required by the school administration. They conducted a study in which teachers were asked about their needs and experiences in their classroom. In this way, they had the opportunity to learn new methods to address their specific needs in their daily practice such as encouraging cooperative learning, implementing constructivist approaches, and motivating students to improve their skills and behaviors. This study also gave teachers a sense of belonging and the feeling of being valuable members of the learning community in their school. For this reason, it is necessary to identify the characteristics of teacher development courses for teachers.

2.2 Teacher Professional Development Courses (TPDC) and Technological Pedagogical and Content Knowledge (TPACK)

Teachers are responsible for developing deep content knowledge in their subject areas and framing the conditions and providing the context to teach that knowledge in their classroom. As they develop their content knowledge and their teaching techniques, they could also integrate technological knowledge using applications or programs to achieve the class goals. This framework can now be described as TPACK. Rogers & Twidle (2013) recognize that to the extent that teachers commit to the benefits of technology integration in the TPACK implementation, it increases the attributes that technological applications can provide as well as the opportunity to increase content knowledge by using technological applications and programs in meaningful and purposeful ways.

An example of a purposeful TPACK implementation is presented by Allan, Erickson, Brookhouse & Johnson (2010) in a study implementing a TPDC named the EcoScienceWorks

(ESW) Project. The project focused on the use of software to involve teachers in the integration of technology in an ecology program. In the project, teachers were asked to develop the ESW curriculum using computer simulations to give students hands-on experiences in an ecology class. Through this professional development course, teachers learned about how using technology to develop the curriculum can lead students to experience science in more realistic and interesting ways. Additionally, teachers learned how simulations can be used, and in this way they increased their technological skills. Before this TPDC, the majority of teachers in the project described their skills as limited in using computer simulations. After the course, all of the teachers expressed they had integrated computer simulations in effective classroom practices and improved their computer simulation skills.

In another study, Harris & Hoffer (2017) identified school districts that were using the TPACK framework in their lesson planning and professional development courses. They invited representatives of these schools and districts to a symposium focused on TPACK. During the symposium, the teachers and school representatives were invited to provide real-world examples of their understanding of the framework, followed by small group discussions and reflections. After the symposium, participants were requested to complete a follow-up interview to gather more data about how they perceived and understood the TPACK framework to be implemented in their districts. The results of this study show the different perceptions people in different districts had about the framework to be implemented in the different disciplines. For example, one of the district representatives affirmed that the TPACK can be overlapped and used to produce environments in which students could learn effectively by developing a curriculum based learning and teaching with technology integration. Other participants of the study recognized TPACK as a connector. For example, the technological, pedagogical, and content

knowledge components are connected to create meaningful ways to design lessons and structure professional development courses to encourage teachers to prioritize students' acquisition of 21st century skills.

2.3 Technology Implementation in Class

The use of technology in the classroom can increase the time that students are on-task, which can result in more engagement and motivation than traditional instruction (Baker & Hill, 2017; Krishnan, 2016; Unal & Unal, 2017). Implementing technology is desirable in all educational subjects; however, it is crucial in science, technology, engineering, and mathematics (STEM) disciplines. Across all educational levels, the time that students in STEM disciplines use technological devices and technology is higher than in social sciences, which is due in part to the integrative nature of STEM. For example, Ntemngwa & Oliver (2018) investigated the implementation of STEM instruction by using robotics in a middle school science class. This study found that the use of robotics technology can be used to effectively improve students' learning. Teachers in this study created activities with robotics programming and science. The purpose of one activity was to support students' understanding of motion, and using programming to understand and apply acceleration, velocity, deceleration, and directional acceleration. Lately, there is an increased interest in understanding how technology can be integrated in K-12 classrooms to improve students' understanding of STEM disciplines and ultimately, to attract more students to pursue a career in a STEM-related field.

Increasing the number of students that pursue a STEM profession is a common goal for many governmental associations such as the National Science Foundation (NSF) and the President's Council of Advisors on Science and Technology (PCAST). However, in order to achieve this goal, it is important to understand how these disciplines are approached at the

different educational levels. An observation-based study found that in middle school and high school levels, teachers devoted more time of their instruction to active learning strategies versus increased lecture-based instruction in the first year and advanced levels in college (Akiha, K., Brigham, E., Couch, B. A., Lewin, J., Stains, M., Stetzer, M. R., Smith, M. K., 2018).

The type of hands-on activities that teachers select for middle school and high school students can be pivotal to increasing student interest in STEM. Schmidt & Kelter (2017) conducted a study in which they looked into science fairs as an extra-curricular way to involve and interest students in science. They found that science fairs can give students the opportunity to select a topic and analyze it in order to present it as a culminating activity. In this way, students can develop different types of skills required in STEM areas such as being conscious of the scientific process and communicating results effectively. However, for certain students, the science fair resulted in a negative perspective about science due to problems in the process they used to present and prove their topics. Results from the study found that the complexity and length of some of the experiments intimidated some students. Another factor is the individual work required for the science fair; some students felt discouraged in this area. At times, it is necessary that teachers guide students to hold their interest in science. A clear example is the creation of STEM after school programs which create more opportunities to give students spaces to experiment and be interested in science, technology, engineering and mathematics.

Some of these after-school programs were also created in order to increase female students' interest in these discipline areas. Creating programs in which female students have hands-on experiences, encouraging them to increase their understanding of different STEM processes and to imagine themselves as scientists or engineers, are extremely valuable nationwide (Newbill, Drape, Schnittka & Evans, 2015; Riedinger & Taylor, 2016; Schnittka & Schnittka, 2016). In addition to after-school programs, it is vital that STEM classes include

hands-on activities and highly interactive tasks that relate to real STEM processes that promote students' interest as well as higher order thinking, decision making, collaboration, and critical thinking.

2.4 Digital Game Based Learning

Technology evolution has allowed game digitalization to proliferate; each year hundreds of games are created that promote and enrich educational goals. Hwang & Wu (2012) found that studies implementing Digital Game Based Learning (DGBL) increased over the last decade. They found that from 2006 to 2010, the number of studies reported increased four times than in the period from 2000 to 2005. This result demonstrates researchers' increasing interest in DGBL and increasing of its usage in curriculum.

DGBL is an educational approach that uses digital games as technological tools to engage, motivate, and involve students in the learning process. DGBL can support students in refining their own learning skills while they are allowed to practice during a gaming session. Papastergiou (2009) identified in-class digital games as engaging and motivational for students. For that reason, researchers all over the world have studied the performance of digital games when combined with educational purposes. For example, *Dimension U* is an interactive digital game that focus on mathematics and literacy skills for students from third to ninth grade. Bragg (2012) describes digital games as a useful tool to engage students and to improve students' time on task, while helping students to actively develop their content knowledge.

Digital games allow students to increase problem-solving and critical-thinking skills while they plan, analyze, and collaborate with their peers using digital games in class (Li, 2010). These skills are labeled 21st century skills and are a desirable goal for students to achieve in their future. Computer-based games also allow students to enjoy educational strategies and increase

their enjoyment in learning through DGBL. For example, Hwang, Hung & Chen (2014) found students' satisfaction in creating digital games around an educational topic. Students used DGBL to play a game as well as create digital games to evaluate their peers' games. In this study, the students should learn about their topic in greater depth. The topics for their game were environmental issues like pollution, global warming, etc. Students created their own digital games and played and evaluated them using a rubric provided by the teacher. This strategy gave the students an excellent opportunity to learn the topic while emphasizing the use of critical thinking skills through using DGBL.

Literature has shown that digital games have been used mainly to measure learning effectiveness and to understand how digital games can be helpful in class. Backlund & Hendrix (2013) conducted a review of studies implementing DGBL. They found that from 40 studies reviewed, 29 reported positive results regarding learning effectiveness. An example of this is presented by Augustin, Hockemeyer, Kickmeier-Rust & Dietrich (2011) who used a digital game to track students' behavior within the game – an approach that allowed the researchers to understand and evaluate students' competence in certain topics like knowledge space theory. In this way, DGBL can be used to evaluate aspects that cannot be evaluated using traditional testing methods. Bragg (2012) found that students that spent more time playing a game during a DGBL lesson had more effective learning than students in non-gaming lessons. It can be said that gaming environments that allow students to be on-task can lead to positive mathematical learning.

There are also studies that could not find positive learning effectiveness with DGBL. Hou & Li (2014) found that students did not show any learning improvement after using a game. The game was called *Escape Room* and was focused on increasing students' knowledge of personal

computer assembly. In the game, students would collect hardware parts of a computer to disable a bomb and escape from a room in 10 minutes. In this study, students could only play the game once, not giving them the opportunity to familiarize themselves enough with the game. Researchers concluded that in order to promote effective learning, students must be familiarized with the game and the goals desired to produce positive learning outcomes.

To measure DGBL effectiveness, All, Nuñez-Castellar & Van Looy (2015) provided a set of actions that can help to effectively value research, including DGBL. In order to have more reliability on DGBL, research has suggested to include follow-up studies to avoid game effects misunderstanding. It is important to minimize instructors' intervention, avoid confusing elements during the implementation, and include detailed descriptions of similarities and differences between the control and experimental interventions.

DGBL has also been used as a motivational tool in classroom settings. Using a game in class can increase students' motivation to learn the subject matter leading to better outcomes in class due to students gaining confidence on the tasks with which they are presented (Bai, Pan, Hirumi & Kebritchi, 2012; Habgood & Ainsworth, 2011; Hwang, Hung & Chen, 2014; Kebritchi, Hirumi & Bai, 2010; Li, 2010; Tsai, Yu & Hsiao, 2012). For example, Kebritchi, Hirumi & Bai (2010) conducted a study using the digital game *Dimension U* for a mathematics class. The game is a multi-player digital game that includes three different game modes according the curriculum level. The purpose of the study was to examine the effects of the game on mathematics achievement and motivation for high school students. The study found that students who played the game reported higher levels of motivation than students who did not play the game. Motivation is a huge element in learning. Tsai, Yu & Hsiao (2012) found that students with low levels of motivation affect the way they learn while using games in class. In

their study, only students who were identified with high levels of learning motivation could transform that motivation into actual learning while using a digital game.

There are other educational purposes that have been tested with digital games such as the use of games to interest students in their learning activities and to allow them to increase their knowledge (Afari, Aldridge, Fraser & Khine, 2013; Bragg, 2012; Manusos, Busby & Clark, 2013). Bragg (2012 a) states that a DGBL strategy can be more engaging because bring fun to students while they are learning. In that sense, digital games should challenge students to solve problems in the game; for example, solving equations to advance levels. Manusos, Busby & Clark (2013) describe that games can be challenging, but they also are also rewarding for students because while they are engaged, and they have fun playing digital games within their lessons. The literature also shows that DGBL has been applied in different educational settings to measure spatial abilities (Lowrie, Jorgensen & Logan, 2013; Yang & Chen, 2010), student satisfaction (Afari, Aldridge & Fraser, 2012), and self-efficacy (Hung, Huang & Hwang, 2014).

2.5 Theoretical Framework

Researchers like Shullman (2013) and Koehler & Mishra (2008) have stressed the importance of teacher content knowledge by the knowledge per se as well as how teachers disseminate their knowledge instructionally to their students in the classroom. This study is focused on understanding what teachers perceive and learn from a specifically designed science workshop that integrates technology and computational concepts to better understand how they manage their knowledge. The theory presented in this section is Teacher Content Knowledge and its three knowledge types: subject matter content knowledge (SMCK), pedagogical content knowledge (PCK), curricular knowledge (CK), along with the integration of the TPACK framework.

2.5.1 Teacher Content Knowledge

Dissemination of teacher content knowledge can be a complex task. For that reason, Shulman (1986) proposed a theoretical framework to better shape the way that teachers model and transmit their knowledge. This framework consists of isolated content knowledge in three categories: 1) subject matter content knowledge (SMCK), 2) pedagogical content knowledge (PCK), and 3) curricular knowledge (CK).

SMCK refers to the specific knowledge of the discipline or content possessed by the teacher. This type of knowledge symbolizes the acquaintance with the discipline and its applications. SMCK is equivalent to a teacher's profession or is specifically developed in their teaching preparation courses. For teachers, it is necessary to understand the topic and to disseminate the most suitable and relevant topics in their subject matter in order to prioritize them to be taught to students at the appropriate grade level. For this requirement, teachers should use the second type of knowledge that Shulman (1986) highlights, known as PCK.

PCK is defined as the specific techniques that the teacher will implement or develop to teach the content knowledge. PCK is a set of procedures that the teacher will employ to facilitate student learning. The variety of procedures will depend mostly on the subject matter and its content. Some popular techniques in this type of knowledge are demonstrations, illustrations, simulations, and examples. This type of knowledge also allows the teacher to identify the sections or topics that will be more difficult to understand by the student.

For this reason, it is pivotal for the teacher to develop a deep assimilation of SMCK in order to categorize the topic and select the most appropriate tools and techniques to ensure students' learning. In this process, CK should be operated to build the purpose of the class and

select the content and the way it will be taught during a certain period or school year by the teacher in each subject matter.

CK connotes teachers' knowledge around the curriculum that will be taught to their specific group. For this type of knowledge, there are district and school interests. In this vein, the curricula will depend upon the school philosophy, their mission within the district, their specific population, and the local context the school is situated in. For that reason, the teacher will need to articulate the entire curricula to create a path for integrating each one of the topics into their class. According to Shulman (2011), the teacher will relate their knowledge (SMCK, PCK, and CK) to address their teaching needs in their classroom and to teach using the best way possible according their specific requirements.

2.5.2 Technological Pedagogical and Content Knowledge

The TPACK framework describes how the original teacher content knowledge proposed by Shulman (1986) and educational technology relate with one another. Originally called TPCK by Mishra & Koehler (2006), and after revision, Koehler, Mishra & Cain (2013) recognized TPACK as essential to effective teaching with technology (see Figure 1). In other words, TPACK implies that teachers have a deep understanding of how to represent content using technology, and the technology is used effectively to teach the content knowledge. Technology is integrated as a component of the teacher content knowledge and the teaching topic and not as an accessory of it. This concept of TPACK has evolved after several publications in which researchers have explained in more detail the necessary aspects to achieve technology implementation in the classroom.

For TPACK integration, it is required that teachers understand each of its components not isolated but in collaboration with each other. Namely, it is necessary that the teacher understands

how technology can be used to represent concepts, how technology can be used as a pedagogical tool, and what concepts are easier or more difficult to understand using technology. TPACK is an integration of the different types of knowledge that teachers have in their daily practices to purposefully integrate technology as another component in their instructional and curricular plans. To be specific, TPACK inclusion is when a teacher is conscious of the best type of technological application or software that can be used to fulfill learning objectives that align with the teaching techniques selected.

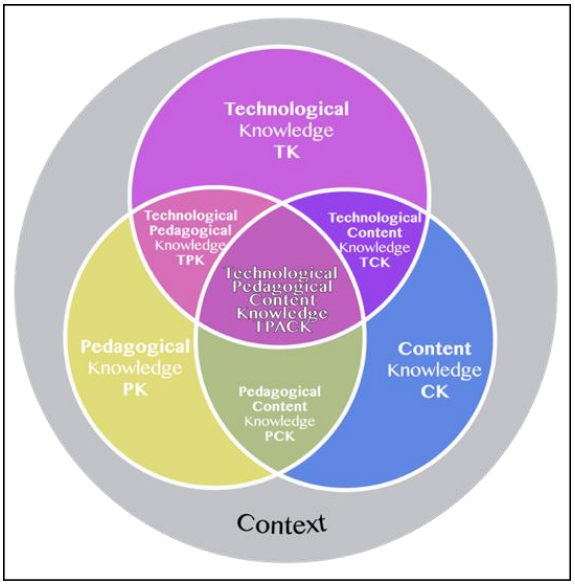

Figure 1. TPACK, (Koehler & Mishra, 2008).

The integration of technology is not an easy task, specifically due to the different type of emergent technologies and the level of understanding that teachers have. For the correct implementation of TPACK, teachers should develop a flexible understanding of how content, pedagogy, and technology interact with one another. These interactions can be complex precisely for the relationships that can result from these three elements. Koehler, et al. (2013) suggest to be careful in order to avoid oversimplification that can result on non-successful experiences in the integration of TPACK.

The purpose of this study is to analyze the TPACK that a teacher professional development workshop (Sol y Agua) would provide to teachers to implement technology in their classroom. In this way, learning their perceptions can lead to better understanding of teachers' knowledge and its application in local schools. This understanding also can lead to identify how the workshop functions to facilitate teachers' understanding of technology and its implementation to teach specific topics in their classroom. Figure 1 shows how the different types of content knowledge are related and how the integration of TPACK creates a perfect integration, giving each type of knowledge a specific role into the framework.

2.6 Conceptual Framework

The conceptual framework for this study comprises information from the Sol y Agua workshop, the literature review conducted around the topics related to the workshop, and the context for the study (teachers implementing computational and technological topics in their classroom). This information will shape the instruments to collect the information from teachers' perceptions about the workshop, what types of knowledge they identify in the workshop and how they will use them for instruction in their own classes. Additionally, the conceptual framework will be used to analyze the workshop and to identify the type of knowledge teachers will have during the workshop. This information will allow the researcher to identify the elements and materials form the workshop that promote stronger teacher knowledge and to determine the level of involvement of teachers in their knowledge acquisition from the Sol y Agua workshop.

This study was used to gather information about teachers' perceptions of the workshop to better understand how the information shared in it can be used by teachers to design instructional plans for their classes. For example, teachers including any concepts or ideas from the workshop in their class lesson plans. Learning this can be helpful for people in charge of developing the

topics for the workshop in order to better understand what teachers think about the topics they learn, the level of understanding they have on the topics and different types of technology, and to understand how plausible it is to replicate that information in the class by themselves. This information can also be used to identify the topics in which teachers had more trouble to replicate, in order to create materials that can be used during the school year about the topics covered in the workshop.

This section will describe in detail each one of the concepts used for the conceptual framework shown in Figure 2. Having these descriptions will help to better understand how this study, and especially the conceptual framework, will draw from these elements to answer the proposed research questions stated in Chapter 1.

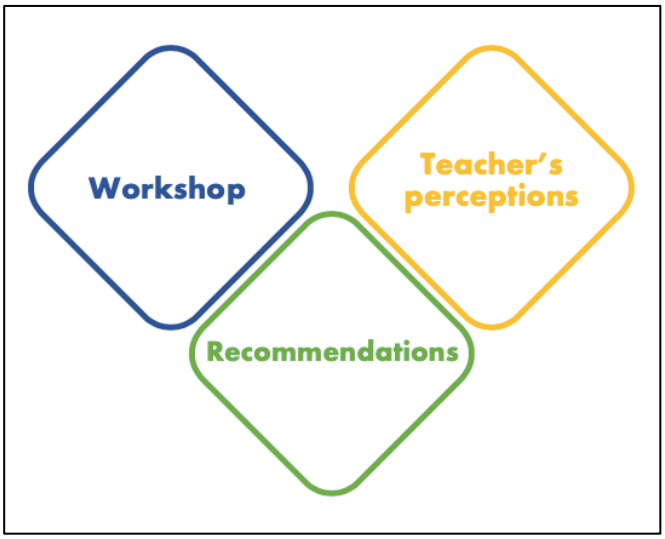

Figure 2: Conceptual framework.

2.6.1 Sol y Agua workshop

This study is centered around a professional development workshop that is specifically designed to infuse technology through a game-based approach to learning. The workshop is a two-day long course designed for middle school science teachers, which focuses on the digital

game, titled *Sol y Agua,* that is used as central piece of the project in which the workshop was created.

The purpose of the Sol y Agua workshop is to inspire Hispanic students to deepen their knowledge in computational science. In order to achieve this goal, the workshop intends to integrate culturally relevant and engaging tools with lessons for science teachers. The major themes that will be addressed in the workshop are: problem solving using computational thinking, algorithm development using python language, and decision making using data visualization and analysis. During the workshop, the facilitator will approach reflection and constructive critique in order to help participants strengthen skills and provide avenues for student and educator empowerment through the use of community projects.

The topics covered in the workshop are: water sources and sustainability, computational thinking, problem-solving, algorithms, intro to python data visualization and analysis, career, data collection, and decision making with competing demands. The resources to be used in the workshop are: *Sol y Agua* game and materials, Google materials and activities, handouts, Otto the robot, Google lesson plan and activities, python activities, and TECHNOLOchica video. TECHNOLOchica is a national initiative to raise awareness among young Latinas and their families about opportunities and careers in technology (Technolochicas, 2017). The workshop is contextualized in the typical science class. The main element and objective in the *Sol y Agua* game is for students to create a park in a specific landscape (mountain or desert).

To achieve this objective, the game includes drone simulations so students can explore the type of land in the Franklin Mountains and in the El Paso desert. In this section of the game, students learn to fly the drone and they explore the landscape to find information hidden in targets along the landscape. In the different game scenarios, there is a wise owl that guides

students through the game. Once students have found the information hidden in the different landscapes, they can move to the science laboratory simulation. In this section of the game, students will select samples of water and soil from the three available landscapes. They are required to measure the pH levels from the soil and water samples. The samples should be at a pH level of 7, and students should use acid or a base to neutralize the samples.

The final stage of the game is to create a park design. Students decide how to manage a budget that has been allocated for them, and decide how to integrate the elements found in the drone activity. With the budget, students should buy water and trees to create the park. They receive points by selecting the most appropriate types of trees, depending on the landscape they have chosen. They also receive points by planning appropriate distance between trees and the visual aspect of the trees depending the target population for the park.

The workshop will use the different scenarios from the game to introduce the topics. However, other elements including python data analysis and visualization will also be used to help science teachers create engaging and culturally relevant topics into their classes.

2.6.2 Teachers' perceptions

According to Efron (1969), perception is a form visualization to make cognitive contact with the world around us; sense perception obtains its meaning in the specific context that it is generated (Toch & MacLean, 1962). Following these ideas, this study uses the term teachers' perceptions to refer to teachers' knowledge recognition from their participation in the Sol y Agua workshop (defined in the previous section). Teachers' perceptions will be gathered asking them directly, in an in-depth interview, what they think about the workshop, and what they note as positive or negative aspects and challenges or rewards for their practice. These perceptions will be crucial to the study in order to understand how the workshop helped participants improve

their science classes by implementing technology and computational topics, as well as to identify aspects that need to be reinforced or complemented to help teachers in the application of the topics during the school year. Teachers' perception will be the main source of data for the present study.

2.6.3 Teachers' knowledge

Teachers' knowledge refers to the different types of knowledge that in-service teachers possesses, as defined by Shulman (1986). Teachers have SMCK, PCK, and CK. Koehler and Mishra (2008) proposed the inclusion of TPACK which includes technological integration into the classroom. This study will refer to teachers' knowledge as the knowledge that teachers have gained from their discipline, and the new knowledge they gained from the workshop they attended. This knowledge can be any category of the aforementioned (content, pedagogical, technological, or curricular), but always referring to knowledge within their class.

2.6.4 Recommendations

The concept recommendation refers to the ideas which emerge from the teachers' experiences from the workshop content and how content could be implemented. Along with the focus groups and in-depth interviews, the workshop structure was analyzed to identify aspects that can be updated, modified, or revised to help teachers from all educational levels and subjects to be more involved with the workshop's content and to apply those contents to their classroom. These recommendations were centered in the way teachers' knowledge was shaped in the workshop, and the way knowledge can be taught in the classroom. The purpose of the recommendation phase is to understand how the workshop is promoting teachers' development of TPACK to engage students in culturally relevant and technological infused classes.

Summary

TPDC can be used as meaningful experiences to help teachers increase their knowledge as well as the topic they teach, and implement technological knowledge in their lessons. This goal can be achieved by implementing the TPACK framework. The teachers can reflect about the correct implementation of technology in meaningful ways for designing their lesson plans and to prioritize their students' 21st century skills acquisition. These skills can be promoted by the correct usage of technology in the class, allowing students to collaborate, use their creativity and imagination, think in critical ways and solve problems using different types of technological applications and educational software around the different subject matters.

This study draws from the TPACK theoretical framework establish a causal relationship between the content and topics covered in the Sol y Agua workshop and the perceptions teachers from different backgrounds and educational levels have about these topics, and the way that teachers consider implementing those topics into their classrooms. All of the components of this study – the theoretical framework, the workshop, and teacher perceptions – are critical to developing a better understanding of the relationships between the topics covered in the workshop and the future implementation and possible adaptations of the topics and materials.

Chapter 3: Methodology

TPDC are the perfect opportunity for teachers to learn, adapt, and implement different technological applications into their classrooms. By having the opportunity to experiment with different programs and applications, the teachers have increased opportunities and options to use and promote hands-on activities in their lesson plans. One way accomplish this is by using the TPACK framework because the technological knowledge is an essential part of the implementation of each classroom activity. To achieve a change in the classroom, the teacher should consider technology as a requisite in their lesson plans.

Technology implementation in the classroom is a purposeful way in which to engage students in hands-on activities which promotes not only their participation and interest, but also promotes their 21st century skills acquisition. For that reason, it is vital that teachers from different disciplines and various educational levels are provided with the opportunity to use different technological applications. The teachers could choose from a variety of applications and software to promote different cognitive skills. This study analyzed teachers' perceptions from a workshop presenting different computational programs, applications, and software, including a digital game to promote students' engagement. The methodology section describes in detail the procedures used to gather information from the teachers to better understand how they perceived the topics from the workshop and how they planned to modify or implement topics into their lesson plans. This chapter describes how the research questions were addressed, and specifically describes the methodology used to collect and analyze the data.

The research questions for this study are as follows:

1. How can the Sol y Agua workshop promote teachers' acquisition of Technological Pedagogical and Content Knowledge?

2. What do teachers think about technology intervention, including a digital game in their practice?
3. What do the teachers note as positive and negative aspects, and challenges and rewards, within the professional development courses they receive in the workshop?

According to Mills (2017), the methodology reflects how the researcher conceives a study. It helps the researcher to define the limits and to settle on how the approach will be implemented. The researcher positionality also will be influenced by the methodology utilized. For that reason, the methodology will provide action plans to answer the research questions by selecting proper methods to collect and analyze data. Flick (2018) states that qualitative methodology is used to understand, describe and/or explain social phenomena. Qualitative research can help the researcher to better understand interactions within groups of people, as well as changes in learning by individuals. This is possible by observing the interactions of participants, listening to what they have to report, or by reflecting about the meaning of their words in the natural contexts they interact with (Litchman, 2012).

A qualitative approach is the best fit to conduct this study, as it allows teachers to express their perceptions and experiences during the workshop and give a valuable insight about how they could learn and implement the knowledge from the workshop. In addition, this approach allows generalizable data provided by teachers to recognize the different educational levels and subjects matter can give a detailed context of the study.

The qualitative methodology will provide the framework for this study which utilizes instruments designed to understand teachers' perceptions, gather information to explain how they feel about their learning and knowledge acquisition, as well as describe how an immersive learning experience can best help teachers to better understand and learn new concepts for them.

3.1 Research Methodology

The research methodology reflects the plan to conduct a study, and will guide the study because it is connected explicitly to the research questions. In this way, the methodology is used as a guide to decide the steps to better understand the studied phenomenon. Within a qualitative framework, there are different approaches depending on the knowledge the researcher desires to gather from the selected topic. The constructivist approach states that the reality is a construct from the human interaction and experiences with the world; on the other hand, the interpretivist approach uses different techniques to understand the realities on certain social contexts.

According to Mills (2017), within these approaches there are some specific methodologies to be employed by the researcher such as ethnography, grounded theory, historical research, case study, phenomenology, and action research. Each of the aforementioned methodologies has a specific outcome. For example, the outcome of an ethnographic study is knowing the culture of the participants in a specified context. In a case study, the outcome is a situated knowledge from a specific context or case. For this study, it is highly important to learn about the circumstances that surround teachers' knowledge during a workshop. This reasoning led to the use of the case study as the best fit to gather data to describe how teachers perceive the professional development workshop and know the details of their learning acquisition.

Litchman (2012) defines the case study as a methodology that can be used to conduct an in-depth examination of a particular case. Ashley (2012) defines the case study as a research design that answers questions such as "why" and "how" specific results occur, in which the research design can be used to explore a phenomenon and to evaluate or explain in detail certain aspects of the phenomenon. In particular, the present study will examine a professional development workshop in order to understand how teachers perceive the topics they learned and

understand how they could implement some of these topics such as computational thinking, algorithms, and data visualization in their classes. This case will be explored from the teachers' perspective, as they have expressed their experiences and from the educational perspective using the TPACK theoretical framework. The case will be analyzed to try to better understand its contributions to teachers' technological pedagogical and content knowledge.

3.2 Research Methods

Interpretivist approaches are selected by researchers for their interest in understanding how people in determined contexts construct their experiences. In other words, these approaches examine how different individuals sharing the same conditions perceive a shared reality which, in turn, results in multiple perspectives from the same phenomenon that the researcher is working to analyze. These perspectives will be explored by analyzing participants' multiple perceptions, beliefs, and interpretations of a specific case, for example the Sol y Agua workshop. (Williamson, 2018).

Under the interpretivist umbrella, there are specific methods utilized in order to collect and analyze the data that will guide the researcher to sufficiently address the research questions and the purpose of the study. The case study requires specific planning and preparation to collect, manage and analyze the data. Instruments which will best prepare and answer the research questions, and plan the collection, transcription and analysis of the data will be selected. The case study allows the researcher to answer the how and why of a specific phenomenon due to the personal and in-depth interaction that can be created with the participants. This in-depth interaction with the participants has to be initiated by selecting the most effective methods. For this reason, the study will utilize focus groups and interviews to collect the data.

The next section will describe in detail how these methods will be utilized in this study to identify the characteristics of the group of teachers participating in the study, to answer the research questions, and to explain to what extent they can be used to better understand the phenomenon presented in this study.

3.3 Data Collection

This section will describe each of the methods for data collection that will be used in the present study, and how this data will be used to explain teachers' perceptions of the workshop, and to understand the workshop's contributions to teachers' TPACK. The methods, as mentioned before, are from a qualitative perspective, and the purpose of the data collection is to gather meaningful information that can help the researcher better understand the experiences of teachers in a professional development workshop. The data collection methods to be used are focus groups, interviews, and a survey.

The in-depth interview, as described by Warren (2012), is a social interaction that negotiates the researcher's interest in the topic and the participant's experiences in a situation around the interest topic. The interaction is based in a set of planned questions that will explore participant's experiences and will give the researcher details about their perceptions, experiences and thoughts about a specific phenomenon. For this study, the researcher prepared a set of questions that best reflect the research questions, then interacted with teachers who attended the Sol y Agua workshop and consented to participate in this study. The interview and the focus groups were designed to help the researcher understand each participant's experience in the workshop and how the workshop activities can be implemented or replicated in their classroom. The survey is designed to gather all the background information required to better understand the

characteristics of the group of teachers that will attend the workshop, their teaching experience, and their expertise in technology implementation in their classrooms.

In order to conduct the collection data methods, the study used informed consent forms given to potential participants. These forms included detailed information about the study; the purpose of the study, the type of methods used to collect the data, the participation expected for the participants, and the time they were expected to participate in the study. Israel (2015) describes the consent as a requirement to any social researcher. It is necessary to first explain the process of the study to participants, followed by asking for their willingness to participate in the study. This is necessary for the researcher to develop certain strategies such selecting and creating a message to communicate with potential participants, and explaining the study to make sure that participants understand the implications of their participation. If they agree to take part in the study, participants signed a form. This form included the details of the study along with the potential actions that were required from them in taking part of the study.

The informed consent included participant's engagement in the study. The next section describes the methods for data collection used for this study.

3.3.1 Survey

According to Fowler (2009), a survey is an instrument that asks people about themselves. The survey asks for information that can be comparable across the population, and the data can be categorized and contrasted to better understand the population being studied. Surveys are questionnaires that have different sections that ask for specific information such as demographics, experiences, or abilities. Tanner (2018) describes a survey as an instrument that collects data to explain the characteristics of a population, behaviors, characteristics, or opinions that can be used to predict future actions. The survey can be used in different ways to collect the

data such as printed or electronic questionnaires, phone or face-to-face interviews, and observational techniques.

In order to have enough data to fulfill the study purposes, it is necessary to identify the main purpose of the study to design the categories of the survey and the questions that will help the researcher to understand the population that will be studied. Therefore, it is required to consider the type, size, and availability of the population to plan the survey execution and data collection. For this study, it was essential to know basic background information about the teachers such as group age, teaching experience, and the grade level they teach. It was also significant to understand how they have used the TPACK framework in their classrooms to better understand the potential they have to implement the knowledge, applications, and programs from the Sol y Agua workshop. The survey used specific questions to gather information about their personal, technological, pedagogical, and content knowledge background.

As described above, the present study used a survey, a focus group, and in-depth interviews to ask participants about their background and their experience in the Sol y Agua workshop. See Appendix A for the protocols used to guide participant interactions.

3.3.2 Focus group

The focus group is a collective conversation that explores common perspectives or experiences of participants that are immersed in the same context. This methodology implies a group of participants with similar backgrounds and having similar experiences. In this particular study, the participants are teachers who attended the professional development Sol y Agua workshop and agreed to participate in this study. Participants were guided by the researcher who encouraged them to share their experiences in a discussion about their participation in the

workshop. This methodological approach emphasizes not only their personal opinions, but also discovers ways of understanding how the members negotiate their experiences and perceptions in the workshop (Liamputtong, 2011).

3.3.3 In-depth interviews

In-depth interviews are interactions between the researcher and the participants in a study. Mears (2012) defines in-depth interviews as interactions that are used to investigate what a participant knows about a topic; how they would define it. Johnson (2002) states that the purpose of in-depth interviews is to gather detailed understanding of an event or topic. Therefore, interviewing people who have actively participated in the topic or event is necessary in order to collect capture the same level of involvement as the participants. He affirms that the in-depth interview is not always a rigid process; the researcher can alter the sense of the interview to have more meaningful understanding of specific aspects. Taylor, Bogdan & DeVault (2015) emphasize the importance for the researcher to create links with the participants, the researcher must establish rapport with participants by identifying what is important for them before going directly to the research topic. In that way, the interview can flow around interesting topics for the participants of the study, allowing them to freely express their thoughts.

The in-depth interview should follow specific steps. First, researchers should include an interview protocol using open-ended questions, generally questions asking how or why. Bogdan & Biklen (1997) affirm that open-ended questions could be used to obtain as many details as possible; teachers expressing their thoughts with more freedom. In this way, participants can answer with their own words, when explaining the phenomenon or topic. It is crucial to have a semi-structured format, a set of questions to guide the interaction, to link them to the topic or phenomenon. It is also important to ask for clarification or in-depth explanations of the responses

by participants, especially if their answers were not sufficiently clear. Finally, it is highly recommended recording the interview and to have notes about verbal and non-verbal reactions to the questions. This extra information can be used to make sense of the responses gathered from interviews (Guion, Diehl & McDonald, 2001).

Taylor, Bogdan & De Vault (2015) assert that in the in-depth interview, the researcher should avoid making judgements about the information collected from the interviews; the data should remain as collected from the participants until the analysis process is completed. One highly important aspect of the interview is to let the participant talk freely, paying attention to how they are responding, only intervening when the answer is not clear, and to be sensitive about what they have to say about the topic.

3.4 Data Analysis

3.4.1 Survey Analysis

The survey was administered online and the data is available from a web page. The data was categorized then analyzed using descriptive statistics to calculate averages in the group age, years of experience in teaching, disciplines, etc. The data were also categorized to understand the characteristics of the teachers that agreed to participate in the Sol y Agua workshop. The categories of the data include years of experience in teaching; subjects or disciplines taught; teachers' perception of their technological, pedagogical, and content knowledge in terms of a Likert scale (very poor- very good); and specific technological applications, programs, and software that teachers already knew previous to the workshop. The survey also included data about their teaching techniques and classroom management. The data was used to create a general context from the participants and better understand the group of teachers that attended the Sol y Agua workshop.

3.4.2 Focus group data analysis

The focus group audio file was transcribed. The transcription file was analyzed to find codes that were identified by analyzing the nature of the communication from the participants. After a first round of analysis, the codes were grouped in categories that represented the different topics mentioned by the participants during the focus group. The categories were analyzed in function of the research questions and reorganized and relabeled to better represent teachers' ideas. A final list of five codes or themes emerged from the data to answer the research questions related to teachers' perceptions and recommendations about the Sol y Agua workshop. As explained in the previous section, the codification will allow the researcher to identify categories or themes within the data. It is important to find the initial nodes from the data that will guide the interaction. In contrast with the in-depth interviews, the focus group is an interaction with a group of people, therefore it is highly important to find the nodes that better support the research questions responses. Once the nodes are identified, it will be easier to create the categories in which the interactions emerged.

Having the data organized into categories will allow more details to answer the research questions. The data from the focus group and in-depth interviews will be contrasted to identify possible similar codes. The codes will help the study to answer the research questions.

3.4.3 In-depth interview data analysis

The in-depth interviews were transcribed. The files will be kept separate by participant pseudonym. The interviews were analyzed to find codes. Gibbs (2012) defines coding as identifying themes in data with labels categorizing the data into main themes. Coding allows the researcher to identify patterns discovered in the data. These patterns will give sense to the study. The codes in the research were named after a short word or phrase that captures the nature of the

context or the meaning of the interactions; the codes will make the analysis process easier by categorizing participants' responses into groups of data with similar characteristics.

To create the codes, it is first necessary to identify preliminary codes that guided the analysis. The codes were analyzed to understand the information they are reporting, but mainly to understand the patterns that form from the different cases around the studied topic. The patterns were used to understand teachers' perceptions about their experience in the workshop and the plan they have to adapt and implement and the topics and applications from the workshop in their classrooms. The codes that emerged from the interviews were around the technological, pedagogical, and content knowledge, in this way the interview allowed the researcher to answer the questions regarding if the Sol y Agua workshop allow teachers to acquire the TPACK to implement in their classrooms.

Summary

The qualitative methodology allows the researcher to understand the experiences of the participants in a determined social interaction. More specifically, the interpretivist approach gives the researcher the opportunity to answer the questions about how and why the social interactions shape a specific topic. In contrast, the quantitative methodology will help the researcher to characterize the context of the participants and better understand their personal and professional backgrounds, to set up the factors that involve the Sol y Agua workshop and their participants. The case study reflects how participants sharing similar backgrounds and experiencing similar circumstances perceive the phenomenon.

The present study utilizes the case study methodology and focus group and in-depth interviews to understand how teachers participating in a professional development workshop perceive the topics and how they could replicate or implement them in their classrooms. The

survey highlights the backgrounds of the teachers participating in the Sol y Agua workshop and how their characteristics shaped their participation in the workshop. The data collection and analysis were crucial steps in this study to answer the research questions. To achieve this, it was necessary to set the path that the collected information followed before and after the analysis. This information was used to support this study by describing teacher experiences and thoughts about a professional development workshop.

Chapter 4: Results

The purpose of this study is to analyze the TPACK impact that a teacher professional development series of modules (Sol y Agua workshop) provides to teachers in order to implement new technology in their classroom and to understand the perception of their participation in the workshop. To accomplish this objective, this study used teacher surveys, focus groups, and personal interviews to understand the level of TPACK skills teachers received from the workshop.

This section includes the detailed results obtained from teachers using the different instruments before, right after, and two weeks after the Sol y Agua workshop. The first section includes detailed demographic information from the teacher survey. This information was used to create a context and to better understand the teacher population that agreed to participate in the workshop. This information includes demographic information as well as information regarding teachers' experiences and perceptions of their technological, pedagogical, and content knowledge. The second section includes detailed information from the focus group. The focus group was conducted right after the workshop ended. The focus group involved 12 teachers who agreed to participate in this study and share their perceptions of the workshop. The last section of this chapter includes detailed results about the in-depth interviews that were conducted four weeks after the workshop. This section includes data from nine teachers who also agreed to participate in the study and implement some of the topics, programs, or applications from the Sol y Agua workshop. The data in this chapter is presented using pseudonyms to protect the identity of the teachers that agreed to participate in the study.

4.1 Teacher survey results. Sol y Agua workshop participants' context.

The teacher survey was required as a prerequisite for the workshop. All teachers that agreed to be part of the workshop were asked to complete a Google form provided online (see Appendix A). The form included four sections. The first section contained demographic questions like gender, age group, and ethnicity and questions about teaching including years of experience, grade, and subject. The second section was composed of technological knowledge questions to measure teachers' overall knowledge of technology, digital games, and technological applications and their implementation in the class. The third section was composed of pedagogical knowledge questions which probed teachers about their teaching approach, types of materials, evaluation methods, and classroom management. The fourth section was composed of content knowledge questions which asked teachers about the topics for their class, and the topics that could be taught using technology.

In total, 51 teachers answered the survey. From the total, 66% were female teachers and 34% were male teachers. In terms of age, teachers were asked in a multiple option question including group ages as their choices. The choices were: a) 25-35 years old, b) 36-45 years old, c) 46-55 years old, and d) 56-65+ years old. The answers of this question show that 29% (15) of the teachers reported being between ages of 25-35, 47% (24) reported being between ages of 36-45 age group, 20% (10) reported being between ages of 46-55, and 4% (2) reported being between the ages 56-65+. The majority of teachers reported being between the ages of 36-45.

In terms of ethnicity, teachers were asked in a multiple choice question. The options were: a) Hispanic, Latino, b) White, c) African American, d) Asian, e) American Indian or Alaska Native, and f) Pacific Islander.

The answers of this question show that 84% of teachers (43) reported being Hispanic or Latino, 12% of teachers (6) reported being White, 1 reported being African American, and 1 reported being Pacific Islander. As can be noted, the great majority of teachers identified themselves as Hispanic/Latino reflecting the population of El Paso.

For the question "years of experience in teaching", 13 teachers reported from zero to five years, 13 teachers reported from five to ten years, and 25 teachers reported more than 10 years of teaching experience. The teachers that attended the workshop taught at all different grades as can be seen in Table 4.1.

Table 4.1
Teacher Participant Grade Levels

Grade level	Teachers
Substitute	1
Pre-K	1
Multiple grades	6
6th grade	1
7th grade	2
8th grade	5
9th grade	6
10th grade	3
11th grade	8
12th grade	7

The group of teachers that participated in the Sol y Agua workshop taught in all different disciplines. Technology was the discipline with the most teachers participating in the workshop (11), followed by science (8), math (6), and engineering (4). Other disciplines represented were business, reading, Spanish language arts, college ready, criminal justice, etc.

To better understand how the teachers perceived their technological, pedagogical, and content knowledge, they were asked with specific questions about their knowledge and how they used or incorporated some of these aspects in their classes. For example, for their overall knowledge of technology in class, 20 of the 51 teachers reported their knowledge as fair, 12

teachers reported a very good knowledge of technology, and 2 teachers reported a very poor knowledge of technology

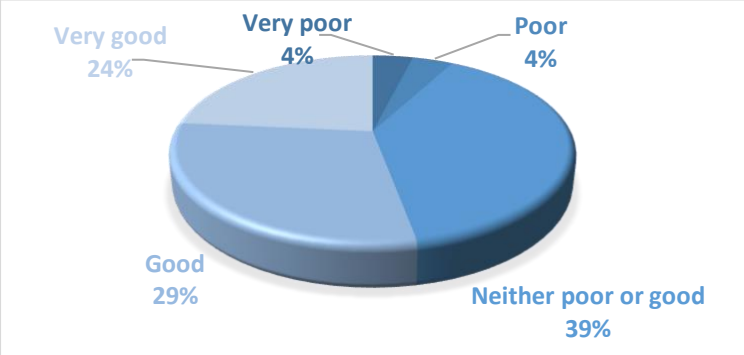

Figure 3. Overall teachers' technology knowledge.

In the same section, teachers were asked to describe what kind of technology they used in their classes. This included the different types of technological devices and applications used for their classrooms. Some of the applications mentioned in this section were: VEX robotics, YouTube, Quizzlet, virtual labs, nearpod, Kahoot, Google classroom, Edmodo, Adobe programs, computers, Power Point presentations, and Microsoft Office, among others.

Those teachers that answered *yes*, were asked in an open-ended question to mention the applications. Table 4.2 includes the list of applications teachers reported using in their classes.

Table 4.2
Technology Applications Used by Teacher Participants

Coding and gaming	**Software**	**Online apps**	**Learning management systems**
MOS	Google apps	Keyboarding	Clever
Coding	Word	3d printing	Remind
PICO-8	Power Point	Gimp	Nearpod
Anaconda	Excel	Plickers	Google classroom
Python	Sway	Aleks	Blackboard
Processing	Office	myON	Schoology
VEX EDR robots	Google docs	NoRedInk	Class kick
Autodesk inventor	Adobe suite	cogAT Test	Classroom screen
Robot C	Skill applications	Rosetta Stone	Edmodo
J Creator	Google forms	Duolingo	Padlet

Table 4.2 (continued).

Coding and gaming	Software	Online apps	Learning management systems
Unity	Office 365	Kahoot	Everfi
CAD Suite	Google ecosystem	NWEA	
Code.org	Microsoft	Khan Academy	
Game lab	ecosystem	YouTube	
		Apple iBook	
		Bulb	
		Quizlet	
		PBS kids games	
		Imagine math	
		I-station	
		Little bird tales	
		Google sites	
		Typing.com	
		Interactive videos	

The teachers were also asked if they were familiar with digital games; 29 of the total answered “No” and 22 answered “Yes”. Among the games and game consoles that teachers were familiar with *Fornite, Forza, Duolingo, Kahoot,* PS4*,* Nintendo*, GrameFroot, Flow lab, Nitro type iStation, Everfi, Code Combat, Minecraft, Call of Duty*, and *Mario Kart* among others.

In the same technological knowledge questions category, the teachers were asked about their familiarity with programming applications, with a Yes/No question; 33 teachers answered they were not familiar with any, and 18 answered they were familiar with applications. They were asked with an open-ended question to mention the programming application, which they reported as the following: Pico 8, Phyton, Java, Robot C, Scratch, App Inventory, C++, RoboticsC+, code.org, JC creator, Repl.It, IDLE, Eclipse, Android Studio, BlueJ, Codehs.com, HTML, Dreamweaver.

To gather information about teachers’ pedagogical knowledge they were asked questions that related to their teaching and classroom management. The first question of pedagogical

knowledge was related to the teaching approach used in the classroom, in an open-ended format. The great majority of the teachers identified as using teaching techniques centered in the student such as Socratic questioning, peer-led activities, project-based learning, experimental, flipped classroom, student learning individually and in groups, engaging students with technology, holistic, guided collaborative learning, student driven, I do-we do-you do, hands-on, using google classroom environment, student-led. Only 1 teacher identified themselves as using a didactic lecture style.

Teachers were also asked about the different types of materials that they used in their classes with an open-ended question. The materials that teachers used were: computers (Desktop, laptops), cellphones, google apps, books, online resources, mouse trap cars, rockets, CO2 cars, wind mills, vex, lab equipment, presentations, videos, textbooks, manipulatives, foldables, projector, online materials, AutoCAD, software, and 3d printers, among others.

An important aspect related to teachers' pedagogical knowledge is evaluation, for that reason teachers were asked in an open-ended question how they evaluate their students and to provide examples. Teachers indicated they used: tests or quizzes, observing students, completing projects, homework, district assessment and benchmarks, experiments, reviews in class, class discussions, rubrics, gaming, writing activities, presentations, informal assessments, self and peer evaluations, and exit tickets.

The last question in the pedagogical knowledge category concerned classroom management. Teachers identified using rows or seating charts, students facing board, students in groups, hybrid (half face-to-face, half online), power zone, following a pattern (boy- girl-boy), changing layout every quarter, telling students routines and expectations, and lab fixed management.

The last section of the survey was devoted to better understand teachers' content knowledge. The first question asked teachers to briefly describe their experience as a teacher. This question targets their years of experience and the subjects they have taught. Some teachers mentioned that their experience has been satisfying and rewarding. Some teachers discussed that being with students has been a rewarding experience even though they do not have the necessary materials. Some teachers discussed the use of technology to engage students. Some teachers discussed using reflection to learn from their mistakes, be better prepared, and work with other teachers. Some teachers also discussed shifts in their teaching career like changing subject, or grade, while some of them have even changed their position in the schools.

The second question in the survey related to the content knowledge and asked teachers the how they usually taught their required topics to their students. Teacher responses summarized their teaching techniques, such as using online tutorial, videos, and platforms like google classroom to include the materials and assessments, using Socratic questions, class discussions, lectures, experiments, and hands on activities. Some teachers discussed using materials like foldables or promethean boards to introduce topics, internet resources, curriculum and old fashion hard cover books. Some teachers discussed using mini lectures, project-based learning, flipped classroom, and the "I do, We do, You do", and 1-to-1 teaching techniques besides writing assessments and real life experience examples, and interactive notebook notes.

The group of teachers that attended the workshop was heterogeneous. There were teachers from different disciplines, which is reflected in the third question of the content knowledge section where they were asked about the main topics they taught in their classes. Table 4.3 shows the various disciplines the group of teachers had and the main topics they expressed they taught in their classrooms.

Table 4.3
Main Topics Taught in Teacher Participants' Classes

Engineering	Hard Sciences	Language
Computer science	Rational numbers	ESL
Computer literacy	Physics	English literature
Biotechnology	Biology	Essay writing
Coding	Chemistry	
Robotics	Math	
Engineering design process	Science	
Data structures	Biomolecules	
TEKS & principles of applied engineering	Cells	
	Enzymes	
	Precalculus	
	Linear equations	
	Environmental sciences	
	Anatomy	
Applied technology	**Social sciences**	**Other**
Website design	Business	Self-awareness
Photoshop	US history	Character education
HTML	Culture	College readiness
Media	Law enforcement & public safety	Gifted and talented education
CAD programming		
Video broadcasting		

In relation with the topics taught by this group of teachers, they were probed about which topics were the most difficult to instruct their students. Teachers identified: self-motivation, sheets, creating and saving images, coding, probability, critical thinking, biology and anatomy, biomolecules, photosynthesis, spread sheets, using databases, HTML, java, critical thinking, factoring, AP physics, Photoshop skills, grammar, scientific reasoning, computer science principles, finance, independent thinking, vocabulary, cyber security, slope, rate of change, career development, law concepts, speaking, Dreamweaver, environmental science, reading, language arts, and budget.

The last two questions of the survey required teachers to identify a topic that could be enhanced by the use of technology, and how they might integrate technology to teach that specific topic. Some teachers did not have any idea in how to integrate technology for teaching

in their topics, while others considered that all the topics could be enhanced with technology but did not offer specific examples of technological integration. However, some of the teachers provided the topics they considered would benefit the most from technological integration. In their answers, two big uses of technology were identified: simulation and application of technology in the class. In one hand for application, disciplines included were business classes to teach students how to create excellent documents. Programming in creating easy to understand step-by-step lessons. For computer science including robotics to the stew. For the linear relationship topic, the ideal way to integrate technology was suggested to include real world examples that involve slope, linear relationships, and constant rates. Some teachers suggested technology could be integrated by using web quests, and games for the visual representation of topics, and the use of data collection as means to assess, review, and teach students. For topics like culture and media, they reported using video interactions. For the grammar and vocabulary topics teachers suggest the use of interactive sites to make grammar fun and engaging. Along with using sites to help students create annotated bibliographies. For the linguistics area, specifically for the sign language topic, teachers suggested integrating technology by making their very own videos in sign language.

Simulations were suggested as methods of technological integration in physics, chemistry, and biology. For CS giving students the programming project to apply what they are learning, and for math using technology as a visual representation for trigonometric functions. For the transformation of topics topic, using software to compare the transformed equation with its parent equation to be able to visualize the changes made. For the topic, mechanisms of biology using visuals that can help students to make visual connections with the topics, to design their own and to investigate more ideas. For the math area, specifically for finding the volume,

teachers suggested to use software to graph a curve and pick the axis of revolution, in that way students could visualize the figure and find the volume. For the college and career development area, teachers suggested using more interactive tools including real-life situations like getting and keeping a job, financial literacy, and work place skills. For the physics area, teachers indicated that using virtual labs and demonstrations could be useful to integrate technology. For the transformations, dilations, rotations, translations, and reflections topics could be practical to let students be able to see and manipulate shapes in their different transformations to discover the algebraic rules with their manipulation.

Knowing the background of the professors that participated in the Sol y Agua is important because it gives this study a perspective of the disciplines and subjects that have been taught in the El Paso area, but most significantly, it gives this study a context to better understand how teachers could take advantage of the topics offered in the workshop. These results also are going to be employed to visualize the way that teachers perceived the Technological Pedagogical and Content Knowledge before attending the workshop.

4.2 Teacher sample focus group results

This section provides a detailed description of the results gathered from the focus group. As mentioned in chapter 3, the focus group consisted of teachers who agreed to participate in the study and attended the Sol y Agua workshop. The focus group was organized after the second session of the workshop. From the 51 participants of the Sol y Agua workshop, 12 agreed to participate in the focus group. The focus group was guided by the researcher following a protocol (See Appendix B) asking them questions about the general aspects of the workshop, as well as the technological, pedagogical, and content knowledge addressed in the workshop. The themes that resulted from the analysis were guidance, implementation plans, workshop

acknowledgement, and recommendations. The results in this chapter are presented by themes and to illustrate how teachers integrated the Technological Pedagogical and Content Knowledge in their responses to answer the research questions. Appendix D includes teachers responses related to specific types of knowledge without integrating TPACK for the focus group.

4.2.2 Implementation plans

This section provides ideas and examples with the integration of TPACK reported by teachers about implementing strategies from the workshop into their classes. Teachers from science and STEM fields expressed an ease to implementing the workshop strategies into their classes, such as in computer science and robotics. One science teacher specifically referred to the Sol y Agua game as a means to introduce some of the topics she already had planned for her class. She found the topics she taught matched with the workshop topics covered:

> "I am a science teacher so it's going [to fit] in directly with when we're doing the typographic maps. We study weather patterns, and climate, … there's little other things and I teach TT also. We are doing a lot of project based learning and I mean it's a direct [fit]".

A math teacher expressed that the coding could be implemented in her class, giving the students with more hands-on experiences in class, and adding the required TEKS for their classes:

> "I teach seven grade advanced [math] and algebra just regular. I would probably get those kids and …, it'll be nice to like show them like okay this is how we can apply like the engineering part, the coding. And not because if you tell them 'oh this is in the real world this is what we do' …To actually get the hands on in the math class I think will be awesome".

Other teachers, not in the STEM areas also expressed the activities from the workshop they would like to implement. A business teacher enjoyed the data and analyzing budgets from the Sol y Agua game. A College readiness teacher stated that he would like to include the coding as a new skill set for his students to learn and apply. Some teachers also identified how the computational thinking and critical thinking aspects covered in the workshop could help students to follow directions, and improve the methods they as teachers use to explain.

Some of the teachers mentioned that they as teachers should prepare their students for standardized tests. Some of them were planning to use topics covered in the workshop and the *Sol y Agua* game. Data visualization and different formats to analyze data was another topic covered in the workshop. Some teachers liked having the opportunity to practice with the data and were eager to use them in their class.

Another interesting idea that emerged in the implementation plans was working with other disciplines using the topics and materials covered in the workshop. Teachers started planning to involve themselves with other disciplines in order to create multidisciplinary projects:

> "yeah, especially for my section the whole time I was thinking oh I'm gonna work with the science teacher, I am gonna work with the teacher social study teacher but I didn't think I could just implement it completely just for reading, you know what I mean? I know that I've be told something like why are you bringing this in here, or you should be focusing on this, and whatever it is".

Many teachers also agreed that the content and strategies from the workshop had the possibility to be modified to implement in any class. Some teachers were surprised because of

previous experiences in which only the core topics benefited from professional development courses.

In summary, the implementation plans theme after the topic results shows all the ideas that teacher participants had right after completing the workshop. For them, it was interesting to find out that some of the topics, like topographic maps, fit in their science classes or how the coding was something they wanted to incorporate in their lesson plans. They also mentioned some strategies to use in class like follow directions. This theme reflects all the ideas teachers started thinking for their classes, some of them identified they needed to modify the topics to adapted to their students age, some other identified the topics they would like to include like data visualization, different types of programs like google sheets, and aspects from the game like the business part of it for the business teachers. These themes showed the first ideas teachers developed about the implementation of the Sol y Agua workshop in their lesson plans.

4.2.3 Workshop acknowledgement

This section provides teachers explanation about their participation in the workshop. This section reflects all the feelings and experiences they had with other teachers, materials, strategies, and topics covered during the Sol y Agua workshop.

One of the aspects expressed by one of the teachers was about the new technologies and techniques that are being used, and learned in the workshop: *"*it's good to see what newer things are coming out and seeing what the new methods are you… know we can uhm.. you know add them to our classroom*"*.

For other teachers, the technological aspect of the workshop was a little intimidating and they felt lost due to the organization of the topics and the coding part of the workshop, some of

them mentioned having difficulties or a bit off experience, however some experienced teachers located in the tables helped teachers to understand the process of coding.

Teachers were asked about the rewarding experiences they had in the workshop. A computer science teacher expressed it was rewarding seeing teachers from other disciplines excited with the workshop materials. Another teacher expressed for her it was rewarding to see different disciplines and teaching levels in the workshop, so they could have more options to implement in their classes. Participants of the workshop also expressed the type of strategies they found valuable from the workshop. Another aspect expressed was having the opportunity to participate and share with peers during the group work, to even ask about the questions they could have: *"*... and the accountability to because every group had an opportunity to share out and it was important because everybody knew that eventually it was to be their turn and like that's the same thing and especially when you deal with your groups uhm*"*.

Having the opportunity to share, helped to create a positive environment in which they could share their ideas and work:

> *"*I also liked that it was a comfortable environment that it didn't matter that our group had a different looking poster everybody was using the computational thinking and everybody came out with different things and it was, it was good for everybody to hear different ways*"*.

But also having the opportunity to share doubts in the groups:

> *"*even at the end you said share with your partner you share with your partner uhm any questions you may have and I was like wow that's cool because we never like really ask our kids like talk to your shoulder partner and see what you don't understand instead of saying like something like questions? Any questions?".

From the activities and strategies covered in the workshop, teachers expressed the ones they liked the most, one of them was Otto the robot, in which one of the participants was a robot and another was the commander who told the robot where to move giving simple instructions like walk three steps forward, turn left, etc. Here is one of the comments from a professor:

> "I liked Otto, I really liked Otto just because the fact that you…. It's a visualization of their thinking process but it also allows it to really… and very obviously make a mistake and then you go back and correct that's just a trial and error and then also gives the students the.. the ability to kind of let their personality out. I guess specially of they are the robot, if they are Otto like that allows them to kind…to gives them a space to shine essentially, I liked that*".*

Another of the strategies noted by the professors was use of Python and the coding process during the workshop, here is a comment from a professor that teaches another type of coding.

In summary, the workshop acknowledgement theme reflects the experiences teachers had in the workshop. The results showed how they reacted to the different topics and materials covered in the workshop. They expressed that the workshop showed them how newer things are coming up, some teachers noted how teachers with no experience in coding felt intimidated. Some of them expressed they did not have coding background and it was difficult for them to complete it, but some participants help them to get it. Results also show that some teachers expressed they felt rewarding seeing teachers from different disciplines to be excited about the topics of the workshop, to learn new strategies like the think-pair-share, having opportunities to share in their groups even doubts. Most teachers found it rewarding to learn about Otto the robot because it helped them to be very specific and teach their students the importance of it.

4.2.4 Recommendations

One of the most valuable themes found in the focus group was the recommendations from the teachers to the workshop organization, and topic treatment. This section reflects the comments made by the teachers about different aspects from the Sol y Agua workshop.

When the digital game Sol y Agua was presented to participants group, teachers started wondering about students' reactions, some of them were curious about hear from students about their experiences using the game. Teachers were told about not having the necessary permission to record students, so another comment was: *"*what about like an anonymous survey that they could take at the end where they names aren't given, there no faces or anything to catch that they could put their you know, their experiences…" Participants were giving ideas where to collect data from the students, they expressed their interest in knowing students' perspectives.

One recommendation from some of the teachers were making more emphasis on the workshop purpose, they mentioned they did not have it clear until day two:

> *"*I think from the workshop perspective uhm it probably could have a stronger message at the beginning that this is the topic. Although is called computational thinking but there were a lot of teachers that I was surround that I saw that were kind of intimidated by the technological aspect that was going on*".*

Other teachers mentioned also break down the topics and give them more details about the content from day one. Another recommendation was to make the workshop more "teacher friendly", teachers expressed they would like to have a guideline or format where they could see the objectives, topics, and even some examples to implement the topics from the course to their classrooms:

*"*maybe just kind of like have a not a guideline but a set of parameters that could be revisited", "So maybe have a better format that show uhm how long to…. whatever and then maybe give some examples of you how to use it in the class kind of like the best practices, or layout*"*.

A teacher also mentioned she would like to have more inclusion from other subjects into the workshop and not being so general. From the digital game Sol y Agua one of the participants asked about the availability of the game in Spanish, after mentioning that in the current version the game is only in English, she expressed that having the game in Spanish also could be a good opportunity for students: *"*That's a good opportunity for those students for Spanish classes, they have to you know to translate, they will have to research what that word means and…".

Another teacher suggested to have more devices or gadgets into the topics they covered in the workshop, so he could implement them with their students with disabilities.

One last recommendation from the teachers was to have a little more structure in the course, having the goal written and kind something like an exit ticket: *"*an exit ticket framing your lesson, having your objective…", "that maybe like he said like having the goal".

In summary, the recommendation results include the suggestions that teachers made about the workshop organization and topic treatment. For example, some of the teachers showed their interest to know how students reacted when using the *Sol y Agua* digital game, their conversations, or even anonymous surveys to learn they experiences with the game. For the workshop organization, teachers suggested to have a stronger message about the purpose of the workshop at the beginning, break down the topics for them, to organize the workshop in a more teacher friendly more structured and having the goals, activities, examples. Other

recommendations were to include more subject matters in the workshop, and to include more gadgets for the materials and topics to be able to implement in classrooms with disabled students.

4.3 Teacher sample personal interview results

This section includes the results from the in-depth interviews with the teachers who agreed to participate in this study. The teachers are named under a pseudonym, and all their answers were analyzed using topic coding. The results of this section are presented in terms of the integration of TPACK and categorized under the themes from the topic coding analysis. The purpose of this section is to better understand the way the teachers could or could not acquire TPACK from the topics and materials covered in the Sol y Agua workshop. The framework of this research states that TPACK is the integration of the three types of knowledge into the classroom. For that reason, it is vital to report the results on the basis of the integration of these three types of knowledge acquired from the Sol y Agua workshop: seven participants from the interview, and a case study from an interview with two teachers.

4.3.1 Technological knowledge

In the technological knowledge section, teachers were asked about the technological applications explored in the Sol y Agua workshop. Specifically, teachers were asked if they used any of the technological applications from the workshop in their class.

4.3.1.1 Implementation in class

Into the first theme two teachers manifested they used the coding part in their classes. Teachers saw coding as something they could implement easy and in some topics they have already started in their classes, for example teacher Luna mentioned they used graphic and coding:

"we have them coding we did coding with like graphic… that was really interesting".

For other teachers using some of the applications reviewed in the workshop was more feasible. For example, Laureen, a pre-k teacher, found the *Sol y Agua* game interesting; however, the level of the game is high for her students. For that reason, she looked for something similar to implement in her class: *"*I found other little games with like drones kind of like the basic maneuvering of drones*".*

In this case, she found the drone in the Sol y Agua interesting for her kids, so she used a game using a drone but for pre-k level to teach them some basic direction skills. Only one of the teachers used the *Sol y Agua* game in his classroom. Joe is a substitute teacher who has special need high school students, however the experience with the game was not so positive; some students struggled with the game. Joe's students started using the game, but after the initial exciting part he started losing their attention and concentration:

> "uhm, you know I tried to keep them or I tried to… to keep them focus and… but after a while is like they were kind of getting lost and losing their concentration as far as been able to go like to the next step and so on".

In the end, Joe only used the *Sol y Agua* game for the drone section. He found the content to be a little difficult for his specific group of students.

In summary, after three to four weeks from completing the Sol y Agua workshop, the teachers were interviewed individually. The theme implementation in class reflects the topics from the workshop that teachers implemented in class. wo of the teachers expressed using the coding section despite not being technology teachers. They did it to start getting students interested in coding. A kindergarten teacher mentioned she liked the *Sol y Agua* game but she could not use it with her students in the manner it was used in the workshop. Instead, she will look for more age-appropriate games with drones to teach them basic directions. Only one of the teachers used the *Sol y Agua* game with his students with disabilities. He reported that students only enjoyed the drone section of the game and started losing their attention in other sections of the game.

4.3.1.2 Implementation plans

This section refers to the plans that teachers have to implement topics or strategies that they learned from the workshop into their classroom. This theme appeared because some of the teachers did not have the time to implement some topics after the workshop and before the interview.

Three teachers expressed they did not have the time or the opportunity to implement any of the technological applications because of the certification or testing preparations. For one teacher, it was impossible to include any of the applications because he plans his class at the beginning of the school year and including new material during the year seemed impossible for him.

Teacher Dario expressed he did not implement any of the technological applications, however he was planning to do it after the interview to find the best way to include those applications for his students. For him, it was necessary to share with his students the basis of problem-solving in order to provide them with the most basic thinking skills.

Teacher Nadia expressed she could not implement any of the technological applications because she was working with her students toward their certifications. For Nadia, it was almost impossible to include the applications but said she would like to do it after the certifications were completed. Nadia trains high school students in Business Information Management (BIM). Students in this class learn specific programs such as Microsoft Office PowerPoint, followed by a certification exam focused on program functionality at the end of the school year.

Into the technological knowledge questions, teachers were also asked if they wanted to replicate any technological application from the workshop should they not know how to replicate it in their classrooms and needed help or more information about them. Teacher Laureen

mentioned that in order to include more technological applications, she needed time to adapt them to her pre-K students.

Teacher Jen expressed she would like to replicate the Sol y Agua game, as a business teacher she thought the buying section of the game could be useful for her students. She thought of this section to try something more engaging for students for a topic she consider can be boring for them:

> *"*how to spend their budget, because I do a budget one but it is getting boring for them because everybody knows about it already. I think implementing this other thing to them they could spend more into the budget and the buying part*"*.

Teacher Joe expressed he wanted to replicate the programming part for some of his students that he considers a little more advanced than the others. For him, having special needs students is already a challenge and having a room where students could easily lost their attention could be difficult to implement any of the technological applications from the Sol y Agua workshop.

In summary, some of the teachers did not have the opportunity to implement technological application knowledge in their classes because they were focused on preparing students for certifications or standardized tests. However, they still had plans to implement after the testing or certification. Others would implement it next year. Some teachers expressed that they would like to replicate some aspects of the technological knowledge of the workshop, like the Sol y Agua game for business students, to teach them to manage the budget. The kindergarten teacher mentioned she would like to replicate more topics from the workshop but she needed to break down everything to her students. One of the business teachers mentioned she would like to make an interdisciplinary project with teachers from other subject matters. The

teacher with students with disabilities expressed he would like to replicate the programming part with his students.

4.3.1.3 Workshop acknowledgement

Teacher Luna mentioned that the application that she liked the most was Otto the robot. She did not think of any other technological application to implement in her class, but she expressed the she would like to keep implementing more applications from the workshop.

Teacher Dario expressed that he asked students in his class to learn a new skill, different from the abilities that they have now, and that he would like to give his students the programming skills to learn in groups. He mentioned that he need to figure out the way to do it. Programming was a skill he found important; he expressed his interest in the implementation of Python for his students.

Teacher Nadia expressed she would like to continue working with computational thinking and problem-solving concepts with her students. It was important to her to have students start problem-solving to find information for themselves before asking for assistance. She even found that computational thinking and problem solving fit the certification practices that her students were doing.

Teacher Miguel could not implement any of the technological applications in his class due time constrains. He did however use an online resource he learned in the Sol y Agua workshop. When he was asked about something he wanted to replicate he expressed his willingness to use Otto the robot for the new school year to help students understand programming easily.

In summary, the results of the workshop acknowledged the technological knowledge and applications learned by the teachers. Some of them referred to the robot activity as very useful.

One of the programming teachers mentioned he wanted to use it to introduce his students into coding next school year. He also mentioned he learned a new resource for his students to compile the programs they created. One of the business teachers recognized that computational thinking and problem-solving fit well with her certification practices.

4.3.2 Pedagogical Knowledge

This section includes teachers' responses to pedagogical related questions from the interview. The results are presented under the themes that emerged from the topic coding analysis. For the pedagogical knowledge, teachers first were asked if they had changed any of their teaching techniques or classroom management strategies after their participation in the workshop.

4.3.2.1 Implementation in class

Teacher Jen expressed that she started grouping her students in different groups as she experimented in the workshop and more PBL:

> "yes, the… I implement a lot of the grouping like you have to do a project together before it was like I get them like PBL because they are pretty on their own computer but now I am like [unintelligible] the PBL the technique that I learned at the workshop kind of introduce it without me just tell them okay now you are in groups, now I kind of introduce the robot one so they starting to like working together".

She recognized that students started talking more to each other and now the class is a more collaborative and friendly environment:

> "yes, now they talk to each other more like… because now they are coding and now just giving them the samples that you guys gave us if they do not get it they turn to… it is like more… they … friendly environment and like is not quiet anymore in my classroom,

before it was….they just wanted to do their work and then play games type in or whatever, but now it is like, now they want to go into coding".

After the workshop she modified the way students were seated and noticed that students started thinking more while working in groups instead of working individually.

Teacher Jen mentioned again that being in the workshop helped her to think about how to implement more PBL projects in her class, and how to help students learn from each other and identify other students' strengths and skills:

> "like I told you before uh… I am implementing more PBL, uh… hands on and not just on the computer but hands on like… they, I made them create a robot like a drawing of a robot and that is the robot, so they call it names and this and that so, it is more of an integrating and with that I was able to do, okay group and like okay you are kind of take each a role, you have to decide which role you want to do I am not going tight so, there is kind of thinking on their own now like, what am I good at? What is he good at? What is she good at? So they are talking to each other [loud noise] face to each other to get a good.

For her, seeing her students talking with each other after working in isolation was a surprise. She found during that the workshop was a way to make students enjoy working together.

For teacher Miguel, the seating strategy was significant. He used this strategy when he returned to his students to talk about it, and relate how it is real life:

> "you know when I give you a seating chart you get seating charts in real life it is not just, some teachers invented to… to bother them, uh… so I liked that I could go back and say look we get them you get them, get used to it. uhm…"

Teacher Miguel teaches in a computer lab. For that reason, seating students in different places was not a frequent practice. However, the experience he had in the workshop made him want to try it in his class.

In summary, teachers recognized the group work and the seating strategy as some of the pedagogical aspects they implemented in their classes. One of the teachers recognized that her students' communication was minimal before she attended the workshop. After she participated in the workshop and implemented the Project Based Learning (PBL), her students started communicating more frequently and effectively to work in their projects. Another teacher mentioned that teaching in a laboratory is difficult. He also implemented the seating strategy as a method to encourage students to interact with one another.

4.3.2.2 Workshop acknowledgement

Teacher Laureen and teacher Luna expressed that after the workshop they were more aware of how they mentioned things to her students. She also realized that she was already using some strategies in her class.

Teacher Nadia mentioned that after the workshop, she realized she should explain things better to her students and break things down a little bit more.

For teacher Dario, the workshop helped him to be more critical in the way he asked students to solve the problems he assigned to them: *"*learning how to push for more critical thinking and how to be more thrill in trying to solve certain problems so, uhm… so the problem that I get my students to solve".

Teachers were also asked about to what extent the workshop has changed their teaching practice. Teacher Miguel expressed that he wanted to stop and review everything. For him, it was interesting the way the data was presented and identified.

Teacher Luna mentioned that for her, trying to be more student centered and asking question back to students, so they could change the way the respond to questions. For her it is important working with students to change their elementary school mentality Having a more student centered approach was helping her to achieve it.

Teacher Nadia mentioned that even though she had not had a lot of time, the workshop helped her to be aware of the way she presented topics to students, thinking on different ways to break down things for her students:

> "so far I mean we have not had very much time between the workshop and now and like I said I became very aware of that. I am literally all the time think of computational thinking all that my students are doing this I am so excited my students do the computational thinking, so just being aware that we are doing that in class and to break down make it more detailed by we were… always go back to uhm… the lectures that we were ha… the speakers, for example the robot the whole thing how they have… you have to break down the steps the stuff it kinds of tights into my classroom and the way I… it helps me to teach a little bit better, to make sense".

She tried to rephrase things for her students, and tried to make students understand why they were doing certain things.

For teacher Laureen the workshop was very helpful, she is a novice teacher that was very grateful about the topics and strategies reviewed in the workshop, she enjoyed having examples and topic application, so she could remember things from her teaching preparation, to use with her students.

Teacher Dario expressed that his participation in the workshop helped him to have a better teaching practice and in helping his students to be a better college students. He mentioned

he was struggling before, and then he found the best way to start presenting things to students, but after being in the workshop he found the way to do it:

> "and I had still been struggling until I got here this is the best road map in terms of like okay, this is clear this is a clear uh… progression of how you should start your idea and how you should develop your idea. And that was one thing that I really needed and this really provided"

For teacher Joe, participating in the workshop as a novice teacher and hearing participants from the workshop talk about teaching techniques opened his eyes to new techniques and strategies they will use in their classes, however he realized that some techniques could be difficult for his students. He mentioned he needs to be pretty specific in giving instructions to his students and to help them to achieve the goals for the activities he propose:

> "so I got to CRC students were I have to be almost as specific and simple as possible, uh… you know you got your other class students were you can pretty much give them kind of a general idea and there some are able to follow through it whereas with my kids, uhm… it was just kind of hard for them to understand what I was trying to get them to do, and accomplish*"*.

In summary, the workshop acknowledgement results from the Pedagogical Knowledge reflects what teachers recognized about the pedagogical aspects of the workshop. The majority of the teachers mentioned that the way the workshop was modelled helped them to think more how to present things to their students, to break down the information they presented, to be more critical, and to explain better the topics they teach. Teachers recognized that they needed to break down things for their students, ask more questions to know if they understood. Two novice

teachers mentioned that they learn from their peers in the workshop, and that the workshop opened their eyes to new techniques to implement in their classes.

4.3.2.3 Participants context

The participant context theme includes all their personal experiences that teachers expressed about the workshop. Teacher Luna mentioned it was good to have different strategies and to learn about the different backgrounds of the workshop participants, along with having a good environment to work in.

Teacher Nadia expressed that the workshop was a really good opportunity for teachers, she mentioned it would be useful to have more workshop session for new teacher so they could learn new strategies to implement in their classes. In the same vein, teacher Laureen mentioned being in the workshop was rewarding for her, because she realized that other teachers also have issues to engage students, so she could learn from them even when the majority of teachers were from high school level, she could learned some techniques to modify for her students age and implement in class.

In summary, the participant context theme in the Pedagogical Knowledge reflects teachers' personal experiences about the workshop. One of the teachers expressed that she found it really great to have the opportunity to try different strategies like the think-pair-share and Project Based Learning to witness students making things on their own and try and see how they resulted in the group. Another of the teachers mentioned that for her the workshop was useful and helpful and would like that more teachers had the opportunity to know it. Another teacher mentioned that for her learning that other teachers also have problems to engage students was rewarding because she learned from them in how to manage that in her class.

4.3.2.4 Recommendations

Teacher Joe expressed that he would like to have some examples or teaching techniques to teach the topics from the workshop to special needs students because he had a really hard time trying to teach the topics to his students:

> "going back to the questions, If on the workshop, maybe if they could… because I felt like it was more… focus on middle school and high school which is fine, which is what is was for, but maybe if they could extend it to where uh…. Even those high schoolers that like for the special need kids, if there were some part of that program or workshop, that they would try and…uh…. Teach or give information on how to maybe teach those kind of kids".

For the recommendations theme into the Pedagogical Knowledge, only one teacher mentioned it would be very useful for him to include some techniques to teach the topics of the workshop to his students with disabilities.

4.3.3 Content knowledge

This section includes teachers responses about the content knowledge they received from the Sol y Agua workshop. The results categorized by the themes emerged from the topic coding analysis. For the content knowledge section, teachers were asked if they have used any of the topics from the workshop in their classes. The topics covered in the workshop were algorithms, computational thinking, problem-solving, water sustainability, and programming. Teachers were also asked if they modified their lesson plan after the workshop, and if the topics covered in the workshop were too advanced for their students.

4.3.3.1 Implementation in class

Teacher Laureen expressed that she used the problem-solving topic to try to teach her students real life problems like teaching them not to use a lot of water when washing their hands. She mentioned that her younger students interiorized the topic and they even mentioned it when a problem presented in class:

> *"*I mean it is so funny for me is too funny to hear them like I do not what to do or how…or I do not want to play with this person and then the other are like you have to problem solve it [laughs] and it is too funny because they are so little and they say it genuinely like they learned a new word or they learn something and it is such a big deal for them*"*.

In terms of the lesson plan, she mentioned that rather than modified the lesson plan, she made some notes because she shared the lesson plan responsibility with another teacher, each one prepare the lesson plan every other week.

Teacher Dario mentioned that he used a chapter that was provided in the workshop about problem solving to his students.

In summary, the implementation in class into the Content Knowledge reflects the topics results that teacher expressed about the topics they implemented in class and the way they managed them in their lesson plans. The topics that teachers implemented in their classes was water sustainability for one of the business teachers who linked it with their Word certification program and the PBL. Other teachers implemented the problem solving topic, and another implemented the algorithms topic to teach his students the steps to solve a problem.

4.3.3.2 Implementation plans

Teacher Luna expressed that she did not have the opportunity to use any of the topics due to test preparation. She mentioned that she would like to use some of the topics after the STAR testing. *"*Is kind of like an extra or an extension, so you have a little bit more freedom after STAR"

She mentioned that she would like to use some of the topics with her students during the month after the STAR test. Teacher Nadia also expressed her focus with the certification preparation but she would like to continue using the problem solving topic with her students.

Teacher Miguel mentioned that he would like to incorporate all the topics covered in the workshop because all of them fit his computer science class. He mentioned that his students in the computer science class have a level where they can use programming to make stuff like their own programs for themselves and help them with their education: "but again I think high school kids are in the level where they can program a… they can program things for themselves to uh… help them in their education".

In summary, for the implementation plans in the Content Knowledge as mentioned before, some teachers expressed they did not have the time to implement due the certifications and standardized test. However, two teachers expressed their willingness to implement some of the topics after the test and before the school year finished. One of the teachers mentioned she would like to continue working with the problem solving topic, and another teacher mentioned he would like to implement all the topics related with computer science in his class.

4.3.3.3 Workshop acknowledgement

Teacher Luna mentioned that she did not modify her lesson plan, however the workshop helped her to realize that she was already implementing topics and strategies covered in the workshop:

*"*I think for the most part we kind of kept it the same because we were already implementing a lot of strategies so it is really exciting to be like oh this is what we do in the classroom, so was not anything like super out of the ordinary, it was really nice to see that like it is being taught to other people at school*".*

Teacher Nadia mentioned that the coding part was difficult for them as teachers and maybe she would like to try it with her students:

*"*mmm… maybe at this point is the coding I mean this is a business course so I would love to maybe squeeze some time into kind of go over that, but I think at this point they are still learning how to follow directions, probably once they learn that they could move forward to actually applying that because it was kind of complicated at the workshop for us teachers so I imagine what that*... "*

Teacher Miguel expressed that the themes covered in the workshop can be applied in different disciplines; he mentioned specifically biology:

*"*so, uh… I mean I like the idea of the… the theme of the workshop that you can use it everywhere because I talked to a professor, a Biology professor was, he is the one who showed me the Phyton book, because he was telling me that the data for his Biology experiments took so many spread sheets that a person cannot go through them one at a time anymore, so he has to write a program to analyze the data*".*

In summary, in the workshop acknowledgement theme of the Content Knowledge, teachers expressed their experiences with the workshop. One of the teachers expressed she was glad to see that she was already using some things from the workshop. Another teacher recognized that the coding part was difficult for her, but it was a good experience she would like to include in her teaching. Another teacher mentioned that he realized that the topics of the

workshop could be used in all the subjects. Teachers realized the workshop was a rewarding experience for them and to implement in their classes.

4.3.3.4 Recommendations

Teacher Joe mentioned that he would like to see topics from the workshop like computational thinking applied to other disciplines like reading. As a computer science teacher, teacher Miguel mentioned that it would be a good idea to expand the workshop and make it available on YouTubeso teachers could learn by themselves:

> *"*I would like to see the Sol y Agua program expanded, uhm… also maybe make the workshops available like in YouTube or instructions videos uhm… so that let's say I go back and I tell someone about it, and then they get excited, well how are they going to uh…. there should be… I think if you can make it, make a way so that person can learn at their own by… watching. Because I think teachers do that a lot too, where if they hear about something they only need to know like five minutes if they will be able to use it, and if no then…"

In summary the recommendations in the Content Knowledge came from two teachers. One of them mentioned that it would be valuable to include the computational thinking into more disciplines like reading, in other words, expand the scope from the workshop. The other teacher mentioned that it would be good for the workshop to have the materials and topics in YouTube or videos to share with the teacher. In this way, if they want to learn more about any topic they could do it in their time. That could be useful to expand the knowledge from the workshop.

4.4 Sue and Emilia interview: Ideal Implementation

The research purpose of this study is to analyze the TPACK impact that a teacher professional development series of modules (Sol y Agua workshop) provides to teachers in order to implement new technology in their classroom and to understand the perception of their participation in the workshop. For that reason the study used a focus groups and in-depth interviews with participants from the workshop. This section provides a case from the in-depth interviews from teachers Sue and Emilia who were interviewed together and brought valuable information for this study.

Teacher Sue is between 26-35 years old. Sshe identified herself as white, she has 6 years of experience as a teacher, she is a geologist working as a 7th and 8th grade science teacher in a local middle school, she also work with the Gifted and Talented (GT) students . Teacher Emilia is between 36- 45 years old, she identified herself as Hispanic and has 14 years of experience, she is working as a math teacher for 7th and 8th grade, she teaches algebra and advanced math.

After the workshop, teachers Sue and Emilia, who work in the same school, decided to start talking about the topics and material they reviewed in the workshop. They started implementing and talking with each other about what worked and what need adjustments, even though they could not implement much because both were preparing their students for the standardized test. They implemented some elements from the workshop. Being together brought very useful data for this study, for that reason their interactions are presented together.

Teachers Sue and Emilia are both teachers from Appalachian Middle School from the Liberty school district. They were interviewed together by their own choice. The interview was held in the science classroom while students were on break. When they returned from the break, teacher Emilia asked them to go to her math room while the interview finished.

4.4.1 Technological knowledge

Both teachers used Otto the robot to engage their students into the computational thinking and first step for programming. Both of them expressed it was an excellent activity for them. Working together was an excellent opportunity to share the way the implemented things, to modify things, and to have feedback from each other:

> Sue: "…and I think what has been helpful too is that we have sort of bounce ideas off with each other, okay you know. What worked for you? And your classroom or they kind of like this but they were not sure of that, and so that has been nice. I have forgotten about that activity that we did, so know that you bring it out that is definitely something I want to do as well*".*

Teacher Emilia started teaching first and implementing Otto the robot. She then went to teacher Sue and they shared their thoughts, and have the opportunity to take notes. Teacher Sue used in their class also a hint of programming, she wanted her students start identifying the type of syntax and alignment. For her having the students get frustrated was something good because that helped students to be careful in writing the program and achieve to program the Hello word message:

Teacher Emilia recognized that her students are eager to learn and presenting them something new involving technology is interesting for them and they want to learn. For both teacher implement technology is something extremely important, however they also want to interest more female students into STEM:

> Sue: "and the fact that we are both female teachers we also wanted to try to PL to our female demographic and say that you know you can be a female and be good at Science and Math and go into STEM".

In their school they are doing activities involving STEM, to attract students and all the community, they think middle school is the right moment to start attracting students into STEM. Besides the importance of technology, miss Emilia emphasize the necessity to give students material that engage and interest them besides the preparation for the standard test. Both teachers agreed that using the time after the test, would be perfect to use the material covered in the workshop.

In summary, both teachers used Otto the robot as the initial step to start interesting their students in algorithms and programming. They talked to each other about the implementation, teacher Emilia did it first and talked to teacher Sue about the details, that information allowed her to make annotations and adaptations to implement it with her students. Both teachers agreed that their students were eager to learn new things and that they were going to use the time they had after the standardized test to continue implementing more elements and topics from the workshop. Teachers Emilia and Sue were convinced that integrating more STEM activities in to their classes, could result in more students engaged in STEM disciplines from that age. Teacher Sue also used python to start using programming with her students and identified the importance of let students struggle with the code. As soon as they got frustrated they started being more careful in writing the code and made them proud when they achieve their first codes. Both teachers being female, were thinking on attract more female students into the STEM fields, however they were working in different programs in their school using more technological applications to expand the interest of students in their school to these disciplines.

4.4.2 Pedagogical knowledge

In terms of the classroom management, teacher Emilia recognized the workshop helped her to analyze the way she talked to students, the options to give them the instructions, and to change students seating arrangements to help students be on task. For teacher Sue, the workshop helped her to understand students differences and that some of them do not have the same background

knowledge. That realization helped her to start thing from a more basic level, and being more sensitive with her students, but also to made different groups and move students from their comfort zone.

For both teachers, being in the workshop helped them to identify strategies that they could use in their classes. During the workshop, most of the strategies were modeled in a way teachers could replicate them in their classes. Another aspect that they found important is being on the student side and understand that sometimes as teachers they forget that students may not have previous knowledge of the topic they are teaching and feet lost. Teacher Sue also realized during the workshop how important is to interact with other people to try to make sense of the information:

> "….and we do the same natural things that kids do, we go to our partner…what do we need to do, and those are the things we dim our kids when they are doing in our class, we are saying, you know you do not need to be talking or maybe it opens that conversation, maybe we do need to have that purposeful talk and allow them to kind of have those conversations to help each other out".

Teacher Emilia mentioned that she would like to see the workshop reorganized. She needed more explanation in some of the topics like coding, or having some guidance for people that do not necessarily have a background in coding. Teacher Sue mentioned that being in the workshop was exciting because it showed them how to use technology, and that make them excited about start implementing things:

> Sue: "I remember after the two days together, we walked away from it, we said that was really cool, uh… we really liked what went on in there and I think part of what we enjoyed is you know in our jobs, we are always told use technology, use technology. But nobody ever, says these are the cool things that you can do to incorporate technology, so what you

all showed us was look at all the stuff and this is not even the tip of the iceberg, and I think little fire under us…".

In summary, teacher Emilia recognized that the workshop helped them to analyze the way they talked to students to be more clear, and also tried to change the seating arrangements to make sure students started working with different groups. Teacher Sue mentioned that the workshop helped her to be more aware about their students' differences and to recognize that some of them do not have previous knowledge, and she needed to start thinking the way she presented the topics with her students. Both teachers recognized that the workshop was modelled in a way that could help teachers to replicate them in their classrooms and how to use technology and implement different things in their classrooms. Teacher Emilia suggested to include more explanation in the workshop to some topics like coding, or to include some kind of guidance for teachers like her with no coding background.

4.4.3 Content knowledge

In terms of the content knowledge from the workshop in their classroom, teachers Emilia and Sue shared the computational thinking. Teacher Emilia expressed she introduced the topic to her students as a way to keep them interested and let them know what they will review after the standardized test.

Teacher Emilia mentioned that she modified her lesson plan to include the topics from the workshop. The modification was going to help her to continue with the topic after the standard test. She recognized that the topics from the workshop were very useful for their students because preparing students for the test is boring for them and having some topics STEM related could be very beneficial, and that she would like to implement them the next year.

Teacher Sue mentioned that for her having the workshop was a great opportunity because she was planning to have weather channel with her GT students, and she would like to learn more about coding so she could start creating a weather station with her students:

In summary, both teachers Emilia and Sue introduced the computational thinking topic to their students. For teacher Emilia it was important to introduce this topic to interest students and to show them the material they were going to review after the standardized test. She modified her lesson plan to incorporate the topic as an introduction and then after the test. Teacher Sue also included the problem-solving topic in which she used real life problems. She recognized the importance of the topics covered in the workshop for her students, she also stressed the importance of the topics and mentioned that she could never come up with those topics by herself. Both teachers recognized that the STEM topics from the workshop could be very beneficial for their students.

4.5 TPACK integration

This section includes examples of the integration of Technological Pedagogical and Content Knowledge that teachers expressed in the interview. For example teacher Jen mentioned that she used the water sustainability topic in her business class. She mentioned that her students did not have any idea on how much water they use. She used this topic because she wanted to make her class more interdisciplinary. In this case, she integrated the water sustainability topic, the use of technological programs like Word, and the PBL technique.

She proposed the water sustainability topic and linked to her class by asking students to use the Microsoft programs students were learning in her class to report their research : *"*..and they use the computer like much for that they are supposed to be teaching like Microsoft, so they are using Word and search engine to all that, so they are kind of get the point like… *"*

Another example came from the Emilia and Sue case. Teacher Sue mentioned her lesson plan and she recognized the importance of being in the workshop because it would be impossible for her to come up with those topics. She integrated the Otto the robot topic, then the coding and was thinking about incorporating collaboration to work in groups.

Teacher Sue also mentioned that she used the computational thinking, problem solving and the she used a real life problem when students started having errors in their coding:

> Sue: "I did the same thing with the computational thinking, the problem solving we touch down a little bit, uhm… just when I have them start trying to use Phyton, and when their codes were not working and they were getting back errors, then we had to figure out okay what happen? What went wrong and so there was an element of solving problem into that and, then we talked about relating back to real world stuff, so when your technology fails, what happen? Where did that go wrong there is has to be some sort of troubleshooting that goes into it".

Summary

This section presents some of the data that was collected from the three data sources: the survey, the focus group, and the in-depth interviews with teachers. The survey was used to better know the characteristics of the teachers that participated in the Sol y Agua workshop. In total 51 teachers participated in the workshop, 33 female and 18 male teachers. The majority of teachers (24) in between 36-45 years old, 43 considered themselves as Hispanics and 25 of them have more than 10 years of experience in teaching. 20 teachers expressed that they neither have poor or good knowledge of technology.

From the 51 teachers that participated in the workshop, 12 agreed to participate in this study and completed the focus group. The data from the focus group was transcribed and analyzed using the topic coding. Six themes emerged from the analysis: guidance, workshop acknowledgement, recommendations, implementation plans, implementation in class, and participant context. These themes were used for the focus group and the interviews to describe how teachers expressed their experiences in the workshop and how those comments helped to answer the research questions from the study.

The chapter also presented the interview of Sue and Emilia, two female teachers that planned together the implementation of some of the materials from the Sol y Agua workshop and expressed very good ideas and plans to keep implementing. As female teachers, they wanted to engage more female students into STEM areas, but also they wanted to present more engaging topics to their students because they thought they spend a lot of time preparing their students for the standardize test and they lose their attention and interest.

Chapter 5. Discussion

5.1 Introduction

This section includes the discussion of the results presented in the previous chapter. After the analysis and results introduction, this chapter exhibits how the data assisted to fulfil the purpose of the study and answer the research questions. The first part of this section demonstrates how the literature review was developed around the central topic of this study. Then, a discussion of the data is presented in detail around the research questions, explaining how the data facilitated to answer them and also to describe the level of accomplishment of the purpose of the study. This section also describes how the conceptual and theoretical frameworks were unfolded and analyzed around the data to explain their relationship with the purpose of this study.

5.2 Impact of findings

The stated purpose of this study was to analyze the TPACK impact that the Sol y Agua workshop provided to teachers in order to implement new technology in their classroom and to understand the perception of their participation in the workshop.

To better understand the topic of this study, it was necessary to conduct a literature review to recognize how researchers have previously addressed it. Therefore, the first step was to identify the main topics that surrounded the central idea for this study. For that reason, one of the first topics identified was Teacher professional development courses to recognize the type of materials and instructional techniques offered to teachers in different subject areas in this specific type of courses. This theme revealed that teacher professional development (TPDC) courses in general terms are designed to inspire teachers to implement different strategies in their classes, specially more student centered. These type of courses sometimes have specific targets

depending on the standardized tests or school districts educational targets, which currently are more focused on the integration of technology. For that reason, it is important that teachers have technological support so they could integrate technology in their curriculum. Another aspect noted in the literature is that often the TPDC does not reflect the necessities that teachers face in their classrooms.

After a careful revision of the literature around TPDC, it was necessary to understand how these courses promoted TPACK among teachers. Basically, the literature mentioned how TPACK represented the three types of knowledge interconnection to create meaningful ways to design lessons and structure TPDC that promote twenty-first century like critical thinking, collaboration, communication, and technology literacy. The literature also affirms that using the TPACK could increase the content knowledge by using technological applications.

That assertion gave rise to the interest in the next theme in the literature, technology implementation in class to recognize the way the use of technology has been accomplished and reported in publications. According to the literature, the use of technology is higher in Science, Technology, Engineering, and Mathematics (STEM) disciplines than in social sciences. The literature shown that is highly important for middle school and high school teachers to include activities promoting the use of technology to start interesting more students into the STEM disciplines. There is an increased national interest to attract more and more students to pursue degrees in these areas, and it is pivotal for teachers to start using strategies integrating technology to engage students and provide them with more opportunities to be on task.

One of the technological applications that has been used to engage students are digital games; that has been mentioned before in this study. The Sol y Agua workshop was named after the *Sol y Agua* digital game. For that reason, to better understand the role that digital games have

in educational settings, the next topic for the literature review was Digital Game-Based Learning (DGBL). As mentioned before DGBL is an educational approach that uses digital games as technological tools in educational settings. The literature has shown that DGBL is engaging and motivational for students, and can promote problem solving and critical thinking skills. The research about this educational approach has shown the use of games mainly to measure learning effectiveness and to understand hos digital games have been implemented in the classroom. However, studies have also shown the use of digital games to promote motivation, knowledge increase, spatial abilities, and self-efficacy. A section of the literature has also shown that DGBL has not been effective to promote learning.

After a carefully revision of the literature and to fulfil the purpose of the study that is to analyze the Technological Pedagogical and Content Knowledge (TPACK) impact that the Sol y Agua workshop provided to teachers in order to implement new technology in their classroom and to understand the perception of their participation in the workshop. It was necessary to create instruments that allow the researcher to gather data from the teachers that agreed to participate in the workshop. For that reason, a survey, a focus group and an in-depth interview protocols were created. The data was collected in different moments, for example the survey was administered to teachers before the workshop, the focus group was conducted with a small group of teachers right after the second session of the Sol y Agua workshop, and the in-depth interview was conducted individually with most teachers after three to four weeks after the workshop.

The data was transcribed and then analyzed, for the survey the data was categorized to create a context from the teacher that agreed to participate in the workshop. Then from the total of participants in the workshop, 12 teachers agreed to participate in this study. Those 12 teachers participated in the focus group. They were asked about the Technological Pedagogical and

Content Knowledge, besides general aspects from their participation in the workshop. (See Appendix B). After that only 9 teachers agreed to participate in the in-depth interview, again teachers were asked about general aspects of the workshop and the implementation of Technological Pedagogical And Content Knowledge in their classroom. (See Appendix C).

As mentioned before, the focus groups data was transcribed, then analyzed using the topic coding method, after some round of coding, five different themes emerged. The themes are guidance, implementation in class, implementation plans, workshop acknowledgment, and participant context. These topics were identified because they were related to the study and to answer the research questions.

To answer the first research question: How can the Sol y Agua workshop promote teachers' acquisition of Technological Pedagogical Content Knowledge (TPACK)? The analyzed data was separated by the type of knowledge the teachers referred to, when they answer the questions. This first discussion is from the data obtained in the focus groups. The data is not complete, there are excerpts from the original quotes teachers made, to illustrate how they expressed their knowledge acquisition from the workshop.

Table 5.1
Focus Group Responses

Technological Pedagogical and Content knowledge ideas
good to engage students with technology….
…more Project Based Learning
… incorporated also business topic…

Table 5.1 (continued).

….use the Google sheets in math….
… workshop modelled very good, different strategies…
… in science typographic maps/ weather and climate
…teachers intimidated by coding…
…Interdisciplinary projects…
… teaching the engineering part to math students, the coding…
….coding not easy at beginning….

…new things, new methods…
… give my students the coding, need to find limits to implement…
….learn Python, different syntax…..
… improve lessons to implement in class…
…computational thinking, critical thinking/ coding

To better illustrate how teachers perceived their knowledge acquisition, Figure 4 shows the interceptions between the three different types of knowledge teacher mentioned during the focus group. The figure shows that, teachers perceived more content knowledge to implement in their classes, then in second place pedagogical knowledge, and last but not least technological knowledge. It can be noted that the coding part was difficult for them during the workshop, and that can be a reason they do not felt sure about their implementation in class.

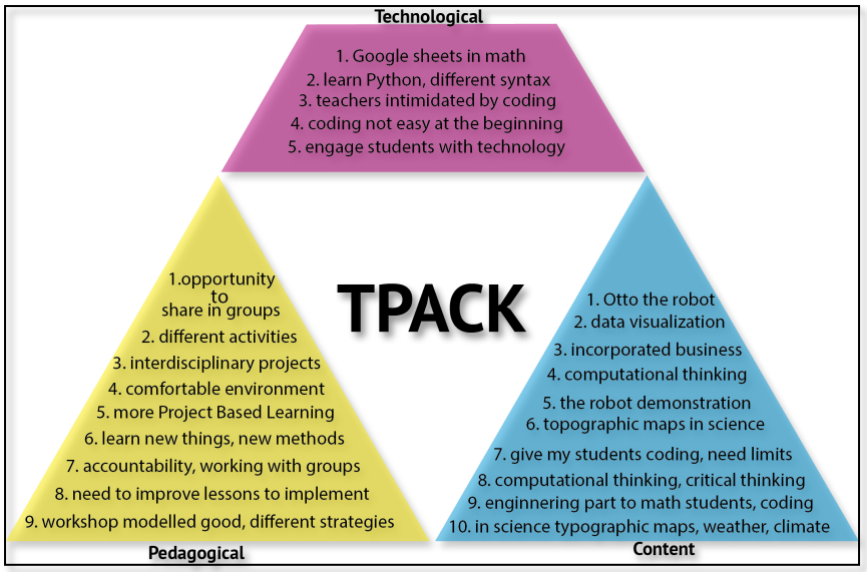

Figure 4. Focus groups teachers' TPACK acquisition.

As mentioned before, the focus group was conducted right after the second session of the workshop finished. After that, the teachers who agreed to participated in the study had between three to four weeks to revise, modify, and implement some of the aspects from the workshop. Then they participated in the interview, where they shared their implementation experiences. For

that reason, it was important to discuss the analyzed data from the personal interviews to better understand how the workshop promoted their acquisition from TPACK. The data from the in-depth personal interviews were categorized by the Technological Pedagogical and Content Knowledge, but also it is categorized under the themes found in the analysis. To answer the first research question about how the Sol y Agua promoted the acquisition of TPACK, only the themes: implementation in class, implementation plans, and workshop acknowledgement were used because they reflect the topics, strategies, and activities that teachers learned during the workshop and they could implement or they were planning to implement after their certification or standardized tests. The data presented in Table 5.2 are excerpts from the original transcribed data.

Table 5.2
In-Depth Interviews, TPACK Acquisition Responses

	Technological knowledge	**Pedagogical knowledge**	**Content knowledge**
Implementation in class	▪ coding ▪ …use game digital games with drones ▪ …Sol y Agua	▪ … PBL technique ▪ …seating strategy… ▪ …be more aware of everything ▪ …use collaboration in class ▪ …explain things better ▪ …being more critical ▪ …be more student centered ▪ …become aware and break everything ▪ …better teaching practice	▪ …multidisciplinary project ▪ …use problem solving with kids ▪ …used materials provided in workshop ▪ …used algorithms
Implementation plans	▪ … want to use Sol y Agua ▪ …programming	▪ …open my eyes to techniques shared in workshop	▪ Can be used in all topics
Workshop acknowledgement	▪ ...Discover python language		▪ …Otto the robot ▪ …computational thinking

The theoretical framework used for this study states that Technological Pedagogical and Content Knowledge (TPACK)is an integration of the different types of knowledge that teachers have in their daily practices to purposefully integrate technology as another component in their

instructional and curricular plans. To be specific, TPACK inclusion is when a teacher is conscious of the best type of technological application or software that can be used to fulfill learning objectives that aligns with the teaching techniques selected. As can be noted in Figure 4, the integration of the three types of knowledge during the pre-implementation was mostly in the same amount. Teachers expressed more difficulty to implement the technological knowledge from the workshop.

For most teacher the coding part of the workshop was challenging and tricky mainly because they did not have coding background, however when they practiced in the workshop they felt better and more confident.

After the focus group, the teachers had time to revise their notes and implement some of the materials, strategies, and topics covered in the workshop. Figure 5 shows how the integration of TPACK occurred in the classroom. This image can be contrasted with the ideas that teacher had for the implementation right after the workshop, and how they could implement after four weeks of the workshop.

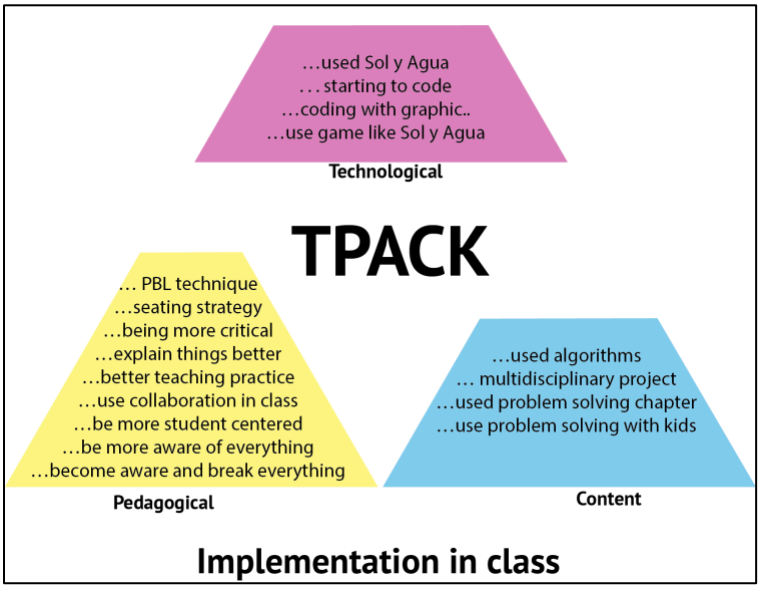

Figure 5. In-depth interview teachers TPACK acquisition, implementation in class.

As can be noted in the image, the implementation after the workshop was not as teachers expressed in the focus group. The integration is not equilibrated, teachers expressed they more easily implemented teaching strategies into their classroom, then some of the content topics reviewed in the workshop, the technological knowledge was the one with less implementation in class. However as mentioned by some teachers, they could not implement much content and technological knowledge in their classes due to the standardized test and the certification exams they were preparing their students for.

Teachers also mentioned that even when they did not have enough time or opportunities to implement the topics from the workshop in their classes, they were planning to implement them later, some of them after the certifications and standardized test, other teachers mentioned that maybe for the next year. Table 5.2 also shows the ideas that teacher had about implementation after the interview, in that case there are more technological aspects that teachers would like to add.

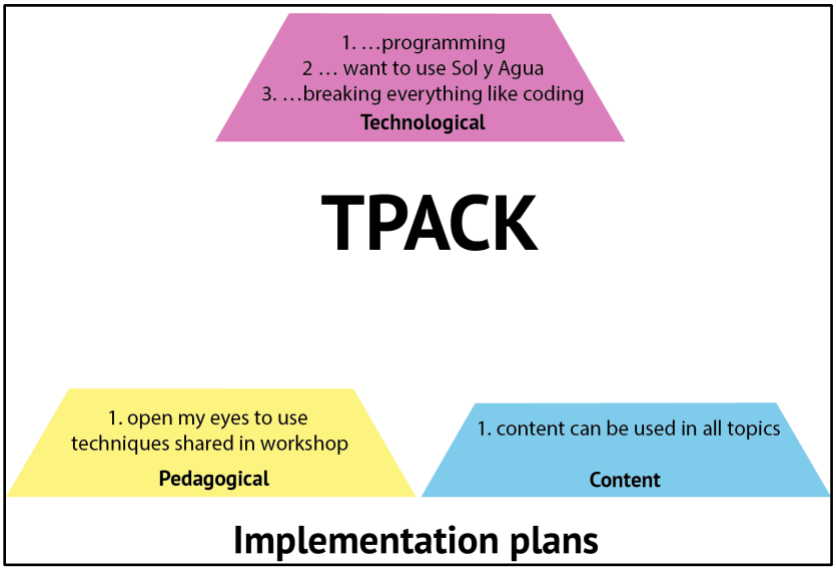

Figure 6. In-depth interview teachers TPACK acquisition. Implementation plans.

As can be noted, the type of knowledge more relevant in teacher responses was the pedagogical knowledge. Aligned with Alshehry (2018) professional development courses are the perfect opportunity to attract teachers to change their teaching techniques. As the results showed, the workshop helped teachers to implement different types of strategies that were more student-centered and were more aware on the way students learn. It can also be noted in the results that teachers are too focused on prepare their students for certification and standardized tests, that they do not have freedom to modify their lesson plans to implement all the topics and technology applications they learned from the Sol y Agua workshop.

In terms of content knowledge, even when they were some topics that teachers identified flexible to adapt in any discipline, like computational thinking, algorithms, problem solving, even coding. They did not find the time and opportunities to implement, however some of them expressed their interest to implement them later with their students. For the technological knowledge, it was a little more difficult to really implement the integration of TPACK for some teachers, the majority of the teachers did not have an engineering background, so the coding or technological applications more specialized were little more difficult for them. As mentioned by Rogers & Twidle (2013) the more teachers know the benefits of integrating technology, more they can be benefited to increase content knowledge, however in this study teacher learn about the benefits, however they expressed not having the time to really implement the knowledge they acquire from the Sol y Agua workshop.

For the integration of the Technological Pedagogical and Content Knowledge, Table 5.3 shows the occasions that teachers expressed in their implementation, that they could integrate the three types of knowledge in their practice.

Table 5.3
Examples of Integration of TPACK

Integration of Technological Pedagogical and Content knowledge
Water sustainability topic, use of technological programs like Word and Project Based Learning technique from the workshop Otto the robot, coding and collaborating with group work Computational thinking and problem solving topics, coding, and real problems

Teachers expressed multiple examples of how they acquired technological, pedagogical or content knowledge, but there were only a few examples when they could integrate the three types of knowledge, Figure 7 show the integration of the three types of knowledge in teacher practices.

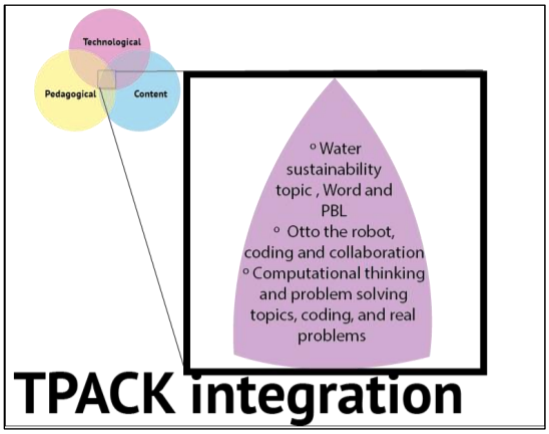

Figure 7. TPACK integration.

The second research question for this study was: What do teachers think about technology intervention, including a digital game, in their practice? To discuss the results for this question, there were used the themes emerged from the analysis: workshop acknowledgement and participant context. The workshop acknowledgement reflects all the feelings and experiences teachers had with other teachers, materials, strategies, and topics covered during the Sol y Agua workshop, and the participant context reflects all their personal experiences in the workshop. Table 5.3 shows excerpts capturing the main idea from the original data analyzed from the focus group and in-depth interviews.

Table 5.3
Teacher Experiences and Thoughts About Sol Y Agua Workshop

Workshop acknowledgement	Participant context
Good to see what is new in technology	Really good having different strategies, good environment
Was rewarding to see teachers from other disciplines excited with workshop	Would be great to have more teachers involved and attend the workshop
Rewarding to see different backgrounds in the workshop	It was rewarding to learn strategies shared by teachers
All groups had the opportunity to share in groups and with partners	-
Comfortable environment	-
Made me more aware of everything	-
Learn how to push more critical thinking	-
Helpful and useful, more teachers need to be aware of it…	-
See other teachers had struggles with students and shared ideas	-
Made me question back students, made them think	-
Helped me to have a clear idea on how to progress	-
No experience in code, a peer explained the basics	-

The majority of the comments about the workshop were positive, teachers thought that it was good to have different strategies, a good environment in which they felt comfortable to ask and share their thoughts, share ideas and strategies with other teachers, and learn to be more aware of the things they already do in their classrooms and be more prepared to help their students to think more.

The third research question for this study was: What do the teachers note as positive and negative aspects, as well as challenges and rewards, within the professional development courses they receive in the workshop? This question had already been answered in part with teacher's

responses from table 5.3. Some of them expressed it was rewarding to see how teachers from other disciplines were excited about the workshop. Some other teachers struggle with coding and they were challenged to overcome it during the workshop. They note positive the collaboration environment.

The conceptual framework for this study was comprised of the Sol y Agua workshop, teachers' perception, and their recommendations for the workshop. The recommendations are an important piece for this study because they represent the opportunities to improve the workshop and have better results in case the Sol y Agua workshop is offered to a new group of teachers.

Table 5.4
Recommendations for the Workshop

Recommendations
Recording of students playing the Sol y Agua game
Stronger message in the beginning about the topic
Breaking the content from day 1
Have guidelines and parameters, more teacher friendly
Include more content from other disciplines
Develop the game in Spanish for ESL students
Include more gadgets for students with disabilities
Frame lessons, include exit ticket, goals for the course
Information about teaching to different types of students
Introduce computational thinking in disciplines like reading including examples

The recommendations for the workshop mainly are about being more teacher friendly and include more examples and content to implement not only in science and engineering but also in social sciences disciplines like reading. One of the novice teachers would like to have more specific examples on how to teach the topics to his special need students. For teachers having support or something that guide their teaching is really important. As mentioned by Rashid (2018) teachers need support to solve the problems they encounter in their daily experiences in the classroom, for that reason it was important for teachers to have some kind of manual and

guidance to help them to better understand the way the topics could be implemented and to enhance their implementation experiences by having this support.

The recommendations for the workshop are presented in Fig. 8, the figure shows how the integration of the TPACK can be achieved by the integration of the aspects mentioned by the teachers during the focus group and the in-depth interviews. The guidance refers to have a handout or teacher manual that guides them after the workshop, in that way they could revise, and analyze the steps for each topic. Recommendations refer to specific examples for different disciplines and how they could be modified to be implemented not only in different disciplines, but ideas in how to modify them to implement them in different educational levels and for different types of students. More content refers to include more topics and material to different disciplines to facilitate teachers the implementation of the material from the Sol y Agua workshop.

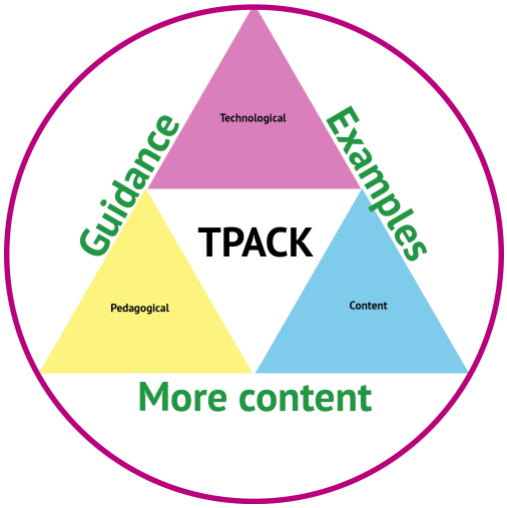

Figure 8. Recommendations for the Sol y Agua workshop.

From the Sue and Emilia ideal implementation it worth to be mentioned that they did not receive any special treatment in the study, it means as the other teachers both of them

participated in the focus group, they had the same amount of time (three to four weeks) to implement the material form the workshop, and then they were contacted for the interview. However, it was their idea to be together in the interview. Their case was presented apart from the other teachers not only because they were together in the interview, but because they presented a lot of interesting interactions and ideas together. The first fact that was interesting was that they were from the same school and they talk to each other about the implementation of the material from the workshop, they could reflect about the implementation. For example, teacher Emilia presented first the activity Otto the robot with her students, then she and teacher Sue talked about it, and they could reflect and make modifications. When teacher Sue implemented the activity in her classroom, she was already made some adaptations.

Table 5.5
Sue and Emilia responses from TPACK

Technological Knowledge	**Pedagogical Knowledge**	**Content Knowledge**
Otto the robot **Python** **Topics involving technology like the Sol y Agua game**	Classroom management Understand students differences More mindful about students	Algorithms Computational thinking Problem solving

Table 5.5 (continued).

Technological Knowledge	Pedagogical Knowledge	Content Knowledge
Coding using c++	Think in students previous knowledge	Modified lesson plan to implement

Another interesting aspect is that their TPACK acquisition was equilibrated, they mentioned aspects from the three different types of knowledge that they used in their classes, for them the workshop was an exciting opportunity to learn different ways to engage their students and different types of programs that they could use with her students.

Both teachers were eager to keep implementing the workshop topics after the standardized test. For example, teacher Sue mentioned that she would like to keep learning coding, so she could keep teaching it to her Gifted and Talented group, she had the plan to create

a weather station with that group, and mentioned that the coding was an excellent opportunity for their plans. Teacher Emilia expressed her interest in keep implementing the computational thinking with her advanced math students after the standardized test, she mentioned they were very curious and enjoyed learning challenging topics.

5.3 Impact on practice

The impact for this study in a micro scale is considerable for the creators of the Sol y Agua workshop. Mainly because the study collected and analyzed a great amount of data during the different stages of the study. First of all, having the data directly from the teachers who experienced the workshop has a substantial value since they expressed not only their involvement in the workshop but also their needs. According to Rogers & Twidle (2013) in order to implement technology in class the teacher professional development courses should reflect teachers' needs. For that reason, knowing some of the needs and experiences that teachers that participated in the Sol y Agua workshop is very helpful to keep building up the workshop and modify its content to correspond to the curriculum needs.

Another impact in the micro scale is knowing the importance that the standardized testing has in the daily practice of teachers in this region. In that way, the workshop could be more aligned with the Texas Essential Knowledge and Skills (TEKS) and topics that teachers need to review in order to improve their experience and they could implement the material from the Sol y Agua workshop not only at the end of the school year and after the test, but during all the school year.

In the macro-scale, this study could be used as a guide to create Teacher Professional Development Courses implementing technology. Even when the data obtained from this study cannot be generalized due to the number of participants, the data is valuable to take in

consideration for the specificity that teachers expressed their experiences in the workshop. As mentioned by Zhang, Parker, Koehler & Eberhardt (2015) the TPDC can enhance the opportunity for teachers to use inquiry and other types of instruction centered in the student. This study presents data about teachers' acquisition of the TPACK and also a set of recommendations to enhance the workshop, the results can be used in similar plans to create TPDC infused with technology.

5.4 Recommendations for action

This study was designed to understand how teachers perceived the Sol y Agua workshop but ultimately to acknowledge if the workshop helped them to acquire Technological Pedagogical and Content Knowledge. After a careful analysis of the data, teachers expressed their awareness about the different types of knowledge offered in the workshop and suggest a series of recommendations to improve the workshop. Being aware of the recommendations that teachers made about the workshop and about the level of association that teachers had with the workshop are a perfect opportunity to take advantage of the data to continue working on the workshop and offer an enhanced workshop to teachers of the Sol y Agua workshop.

The researcher recommends that the creators of the workshop take action to modify the workshop. The first aspect is to make the workshop "more teacher friendly" as expressed by some of the teachers, in other words is to include a hand out or a guide and give it to the participants including the purpose of the workshop, the topics covered, examples, and all the required material for the sessions. A second aspect to modify is the level of complexity, for example one of the most controversial topics was the coding. Even when some teachers were very interested to start coding in their classes, some of them found it difficult and sometimes overwhelming, a recommendation from some of them was to include a guide for beginners.

This study recommends to make all the possible changes to the workshop structure to have more advantages with teachers across different disciplines, after the careful modification of the workshop is recommended to have another round of questions for teachers after the workshop implementation. This could be a regular practice for the facilitators of the Sol y Agua workshop to keep improving the workshop and have more advantages for the teachers that receive the TPDC and ultimately to have more inspired students in this area.

Another recommendation is to expand the scope of the workshop not only in the educational level, but also in the disciplines included in the lesson plan, and the way of disseminate the workshop. The workshop could be benefited with the use of technology to create lessons or examples that complement the face-to-face sessions with YouTube videos or on line tutorials that could enhance teachers experience and the reach level of the lessons from the Sol y Agua workshop, giving teachers more tools to implement the materials into their classrooms and to have a guide at any moment they could need it.

5.5 Impact of methodology

The purpose of this study that was to analyze the Technological Pedagogical and Content Knowledge (TPACK) impact that a teacher professional development series of modules (Sol y Agua workshop) provided to teachers in order to implement new technology in their classroom and to understand the perception of their participation in the workshop. To fulfill this purpose, a qualitative research method was utilized in order to understand teachers' perceptions and if they acquired TPACK from the workshop.

For this study the researcher selected the interpretivist approach. Interpretivist approaches are selected for researchers for their interest in understanding how the people in determined contexts construct their experiences. In other words, these approaches examine how the different

people sharing the same conditions perceive a shared reality, which in turn, results in multiple perspectives from the same phenomenon that the researcher is required to analyze. Under this idea, this approach was used to try to interpret the experiences that teachers had during their participation in the Sol y Agua workshop.

Inside the interpretivist approach the case study was selected to better understand teachers' participation in the workshop. A case study allows the researcher to answer the how and why of a specific phenomenon due to the personal and in-depth interaction that can be created with the participants. This in depth interaction with the participants has to be initiated by selecting the most effective methods. For this reason, the study utilized focus group and in-depth semi structured interviews to collect the data.

The focus group and the in-depth interviews were very useful to ask teachers about their experiences and obtain detailed responses. With these collecting data methods, teachers could express their ideas with a great level of details, and the interactions could be guided, adapted, and even rephrased to let teachers express their experiences the most explicit as possible.

5.5.1 Limitations

One of the limitations of the study was the time that the workshop was offered. As mentioned before the Sol y Agua workshop was offered in February. For that time, teachers were almost at the end of the school year and were focused on the standardized tests and made the topics from the workshop implementation difficult for them. It would be more productive to implement the workshop during summer or at the beginning of the school year to give teachers more opportunity to include the topics and materials from the workshop in their lesson plans.

Another limitation of was the time spent with teachers, a second interview could be helpful to give them a longer time frame to implement topics from the workshop. For the study

could be beneficial more data about the implementation in the class, however as mentioned before, could be better to offer the workshop before the beginning of the school year or a few weeks after, to have more opportunities not only to reach the teachers but to have more valuable data to improve the workshop.

5.6 Impact on researcher

This study was a very rich opportunity to explore a qualitative approach. Having the opportunity not only to be part of the Sol y Agua project in its development, but also to interact with a very diverse group of teachers from the region, was a very strong experience for a novice researcher to learn and create a study that could be helpful not only in a personal level but institutional and outside the community.

The impact of this research opens the path to continue doing research and to explore how educational technology can be implemented to promote the integration of TPACK in classrooms in the West Texas area by creating more opportunities for teachers to use technology not only as an extension of their in-class duties, but as a tool that can help them to achieve their educational goals in different disciplines and educational levels.

5.7 Conclusions

This study was created to better understand how a professional development course could assist their teacher participants to acquire Technological Pedagogical and Content Knowledge, learn what they think about it, and what they noted as positive, negative, as well challenges and rewards from the course.

To answer the questions of the study, a focus group and in-depth interviews were conducted and analyzed. The data showed that the workshop provided teachers with opportunities and topics to implement in their classes, however for some of them it was

impossible to do it because they were focused on the standardized test preparation. Most of the teachers expressed they gain teaching techniques and strategies that made them more mindful about the way they present topics to their students. Some of the teachers also mentioned that the technological aspect of the workshop, specifically the coding part was a little difficult for some of the teachers with no background in engineering or information technologies.

This qualitative study analyzed the level of Technological Pedagogical and Content Knowledge that teacher participants in a workshop acquired. The study analyzed their experiences by using an in-depth interview and a focus group to express how they experienced the different topics and materials included in the workshop and then the implementation in their own classrooms. The study incorporates teachers' experiences in terms of Technological Pedagogical and Content Knowledge and a set of recommendations that could help teachers to have an easier implementation of technological applications and programs in their lesson plans to effectively implement TPACK in their daily practices.

The implications of the study are to make adjustments to the Sol y Agua workshop to enhance its structure and create better logistics to be more committed to teachers needs and offer a more complete TPDC option to learn, adapt, and implement more technological, pedagogical, and content knowledge materials that are created for their specific needs and context.

From this research, it can be concluded that it is essential for teacher professional development courses (TPDC) like the Sol y Agua workshop to include the purpose, guidelines, topics, and examples of activities and modelling to guide teachers in the implementation in their classrooms. It is also important to include some guidance for teachers with some general ideas about the technology to be used in the implementation of the TPDC. It is also desirable to expand as possible the scope of the courses in order to engage not only STEM educators, but also

teachers from disciplines in the social sciences. It can also be concluded that giving teachers the opportunity to learn and use different technological applications and programs can be helpful for them to include more hands-on activities and instruction centered in the students.

The importance of this research results from the experiences that teachers shared about their participation in the workshop and the recommendations they propose for the workshop in order to give them more resources and assistance to include more technology in their lesson plans and activities. These experiences and recommendations can be useful not only for the developers of Sol y Agua workshop, but also for researchers and TPDC designers, to have a better idea of the experiences teachers had and to better plan the contents of courses infused with technology.

The recommendations for future research is to have more studies centered in teachers' experiences to create TPDC that really reflect the classrooms reality and needs. Having teachers' experiences and expectations could be very effective to create TPDC that could impact in the level of TPACK implementation in the classroom and can also be useful to better understand the struggles that teachers have in their daily experiences. Understanding teachers' struggles can be beneficial to create TPDC infused with technology that help them to achieve their instructional goals and their technological needs in their classes.

The recommendations for future practitioners in the educational technology application area is to be aware of the level of practice that teachers should have with any supporting technologies. This is vital in order to plan technology implementation, which is required to consider in the creation of guidelines and background information that could help novice teachers to understand the use of the intended technology. It is also recommended to have

different examples in various education levels to expand the scope of the implementation of technology applications.

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Appendix A

Online survey protocol

The online survey will be saved in an online server (Google forms) and will be distributed to the teachers by Region XIX when they enrolled in the workshop. The survey will be anonymous, the participants do not need to provide their name or email.

Demographic questions

a) Gender: ◯ Female ◯ Male ◯ Prefer not to say

b) What is your age: ◯ 25-35 years

◯ 36-45 years

◯ 46-55 years

◯ 56-65+ years

c) Ethnicity: ◯ Hispanic, Latino

◯ White

◯ African American

◯ Asian

◯ American Indian or Alaska native

◯ Pacific Islander

d) Years of experience:

◯ 0-5 years

◯ 5 to 10

◯ More than 10 years

e) What grade are you teaching?

◯ 6th

◯ 7th

◯ 8th

◯ 9th

◯ 10th

◯ 11th

◯ 12th

◯ Other_____

f) What topic do you teach?

◯ Science

◯ Technology

◯ Engineering

◯ Math

◯ Social Sciences

◯ Other

Technological knowledge questions

a) How would you describe your overall knowledge of technology?

Very poor	Poor	Fair	Good	Very Good

b) Could you describe your use of technology in your classroom?

c) Have you used specific technological applications in your class?

◯ Yes ◯ No If your answer was yes, please list them. If your answer was no, please answer N/A?

d) Are you familiar with any digital games? Yes No If your answer was yes, please list them. If your answer was no, please answer N/A?

e) Are you familiar with programming applications? If your answer was yes, how have you use them in your teaching? If your answer was no, please answer N/A?

Pedagogical knowledge questions

a) How can you describe the teaching approach you use in your class?

b) What types of materials do you use in your class to teach required topics? Can you provide some examples?

c) How do you evaluate your students? Can you provide some examples?

d) Can you describe the way in which you manage students in the physical space of your classroom or laboratory?

Content Knowledge questions

a) Could you briefly describe your experiences as a teacher?

b) How do you usually teach required topics?

c) Can you name the main topics you have in your classes?

d) Which of those topics that you listed above do you find most difficult to teach to your students? Why?

Of the main topics you teach in your classes, which do you think could best be enhanced through the use of technology?

Could you explain how you might integrate technology to teach that topic you identified in the previous question?

Appendix B

Focus group protocol

This focus group is intended to be conducted in the second workshop session. For the focus group participants will not provide their name.

General workshop aspects

a) What did you note as positive aspects from the workshop?
b) What do you think can be improved from your experience in the workshop?
c) Can you describe if something was challenging for you during the workshop? How did you overcome those difficulties?
d) Could you describe any rewarding experiences from the workshop? Why you think they were rewarding?
e) Would you like the add something about your experiences in the workshop?

Technological knowledge questions

a) How do you perceive the technological applications you reviewed in the workshop?
b) Do you consider it possible to use any of the workshop applications in your class? Why?
c) Do you consider you will require technological support to implement any of those application in your class? What type of support?
d) Would you like to add something else about the technological applications in relation with your teaching practice?

Pedagogical knowledge questions

a) Did you gain any new teaching ideas in the workshop? If yes, can you describe them?
b) Have any of the topics of the workshops helped you to plan activities for your class? If yes, can you describe your ideas?

c) In general, how did you perceive the pedagogical aspect of the workshop? Please be as descriptive as you can

d) Would you like to add something else about the pedagogical knowledge you perceived from the workshop?

Content knowledge

a) How did you perceive the level of your topic into the workshop?

b) Have you already use the science content from the workshop in your class? If so, how?

c) How did you perceive the topics in general of the workshop in terms of complexity?

d) Would you like to add something else about the content knowledge from the workshop?

Appendix C

In-depth interview protocol

This interview is intended to be conducted three to four weeks after the workshop had finished. The participants will be randomly selected and a pseudonym will be used during the interview

General workshop aspects

a) Have you implemented any of the activities from the workshop in your classroom? Why?
b) Could you please describe the ideal way to teach the topics you learned in the workshop to your students?

Technological knowledge questions

a) Have you used any of the technological applications from the workshop in your classroom? If yes, how they were applied? If no, why not?
b) Is there any technological application from the workshop you would like to replicate in your classroom, but you don´t know how? What can be helpful for you to replicate it?
c) Would you like to add something else about the technological knowledge from the workshop related to your classroom?

Pedagogical knowledge questions

a) Have you changed any of your teaching techniques or classroom management strategies after the workshop? If so, could you describe them?
b) To what extent has the workshop impacted your teaching practice? Please be as descriptive as possible
c) Would you like to add something else about the pedagogical knowledge from the workshop?

Content knowledge questions

a) Have you included any of the topics from the workshop in your class? If so, please describe?

b) Have you modified your lesson plan after the workshop? If so, please describe?

c) Are any of the topics covered in the workshop too advanced to apply into your classroom? If so, please describe?

d) Would you like to add something else about the content knowledge from the workshop in relation with your classroom?

Appendix D

Focus group results by themes

This first section includes the ideas emerged from the analysis of the guidance theme:

Guidance

This theme referred to all the directives that guided the conversation among teachers. This theme was relevant since the researcher asked participants for clarification, additional details, or to model conversations in order to collect the most accurate data for the study. One of the most significant directives was to outline the study as clearly as possible, for the participants to better understand the study and be prepared to participate in expressing their experiences. For example:

> "*The purpose of this study is to find out how the workshop helped you to acquire knowledge, regarding the technological, pedagogical and content knowledge that you can have in your class…*"

Another important aspect into this theme is redirecting participant interactions. When participants did not answer the question directly, or digressed from the topic the researcher modeled the question, provided examples, or asked more specific questions. For example:

> "*So now we are going to move on to the last topic that is the content knowledge. […]how do you perceive the level of[science or your topic in] the workshop? [For example the level of the computer science addressed in the workshop, the science, [and your] specific […] subject into the workshop"*

In this case participations were directed to their specific disciplines and to made the focus group understandable for everyone.

Included in this theme is also the guidance to next steps into the project. Participants were asked to participate in the study participation in the focus group was suggested as well, and finally in a personal interview three weeks after the workshop. Participants were worried because they were directed to implement some of the workshop applications or strategies into their classes in order to report that in the interview. Giving the teacher clarification about the dynamic for the interview and how they should implement the topics was appreciated by them:

> *"In the interview I'm going to have with you, you can give me more ideas so we can… because I'm going to report for the Sol y Agua team so I'm going to be your source and the person that will be hearing from you and…and writing all your ideas and to giving them to the team, so the game can be… or the workshop can be adapted into your topic."*

The researcher also gave the participants a time frame so they could plan and implement some of the applications, topics, or strategies they learned in the workshop to their classes. The researcher communicated the length of time that participants should consider before having the personal interview to report their experiences implementing the ideas in their lesson plan:

> "*I will reach you by email in three to four weeks, so we can figure out the best time[to] conduct the interviews. […] I am going to [adjust] to [the] time and date [you decide] and the place also if you want […]*"

In summary, the guidance theme results showed the way participants were reminded about the purpose of the study, and let them know about the different parts of it. The results also show how their participation was guided along the interview protocol and by clarifying some

questions to receive the most specific information about their experience in the workshop. This theme also shows the directions that teacher participants received about the next steps in the study.

Implementation plans

This section includes some of the ideas that emerged from the analysis of the data under the implementation plans theme for the focus group:

"[It] is about engaging our students and they're already using technology, so this is one way to really help them [understand] it whatever the lesson is…"

"*I like the way [the workshop] incorporated also the business aspects because all the time you go to workshop [and] it's always about the core classes. This kind of this kind it's uhm…. It applies to everybody… I liked that*".

"*A lot of these kids they know how to handle like the computer better than I do. And they're like five and just kind of a grilling them to like how we can still bring in these concepts to a younger classroom. Because most of [the strategies] are middle school and high school... it's a little - not out of reach - but … kind of harder for me to think of ways of how to implement still for younger kids".*

"*I think it is so good to learn with them but I wanted personally [to] implement after school. My school is very …STEM focus so reading is kind of like yes pass or start whatever".*

"But [I] like the coding 'cause it gives me another thing to throw in. I may have one group that I am saying 'you guys gonna learn how to code something. ….. But I just need to figure out like what the limits are going to be. But this is something that I can throw at them to see kind of how they break it down and how they teach themselves that…"

"I think the way that it was modeled was really good because it incorporated a lot of different activities like the think-pair-share, or like they were… they give you strategies that you could actually use in the classroom and even if you don't teach specifically computational thinking like you can adapt it to whatever subject".

"*And when you do Excel, we are doing it for the certification. They do have a step by step, that way they kind of integrate the robot kind of like 'this is what the step by step, computational thinking is,' so I like that I think I'm gonna go for that one*".

"*In science I mean, absolutely as we start preparing to…to call our blitz… prepare for the STAAR exam we can look at things like topographic maps and fits into the topography that they saw using, you know, the Sol y Agua and the tectonic fits in, weather and climate fits in, to there for my content area direct fit".*

"*So it's following directions so this kind of show[s] me how to improve it. To know how to follow those simple directions 'cause some of them they don't read the directions, don't move on, and get frustrated. And I can tight into the classroom let them know eh you don't realize that you*

know computational thinking, critical thinking are skills to follow directions you need to be careful 'cause if you don't you're gonna mess up with your coding"
"*So like for me, this kids' maybe doing visualization [since] we gave them the data. And just have them see it in different format, to just see how they react. That's probably the first thing I'm gonna try*".

"I liked … showing them the Google sheets because sometimes in math you have kids that are used to being told that they're not good at it or that they can't do it. So like even just showing them little tools and how to create formulas in that way they can still have like a contribution without feeling they're always gonna be wrong."

Workshop acknowledgement quotes

Here are presented some of the ideas that emerged for the workshop acknowledgement theme in the focus group:
"Although is called computational thinking but there were a lot of teachers that I was surround that I saw that were kind of intimidated by the technological aspect that was going on".

*"*for me it was really rewarding to see that my science teachers are excited and that… I mean that I am always you know, 'cause it's gotta be easier for me when I talk to students because I… you have to understand that even though the students know technology that doesn't mean they know programming that's a totally different language and they don't know anything, so when they start implementing it in other classes for me it's gonna be re…. and for them not for me, I mean for me teaching the class but for them it's gonna be really beneficial*".*

"For me in the beginning like the coding like the spaces and I was not used to it for this very particular like were scary you know. Also I, once I did like the first couple of them I was like oh okay, I just got used to it and like I felt more comfortable because the first time I was what am I typing".

"I didn't have the experience so most things I learned I had no idea of how to code anything so it was pretty much like I…I was lucky to have someone next that she… she had computer uhm… the coding and she kind of explained like the basics of what like oh yeah put this and this or this they're called languages and what not, because I had no clue of what like anything".

"there were some people that were not so helpful when we moved the second time, so [laughs] I was like okay [unintelligible] and then I had to figured out myself, but he helped a lot the first time".
For example, a teacher mentioned the organization of the strategies, and that can be used in her classroom:

> *"I think the way that it was modeled was really good because it incorporated a lot of different activities like the think-pair-share, or like they were… they give you strategies that you could actually use in the classroom".*

"*yeah, and also for us of the team, I think is rewarding like you see different backgrounds and different teaching levels because it's open, it's can give us more… more… ways to work with, so*

it's rewarding like we have do more research we have the improve the game, we have to improve the lessons so, to help you implement and to help students learn".

Another of the comments were:

> *"I liked the robot I thought that was kind of like simple and the kids that will actually enjoy it like the actual like the demonstration that they had that was very specific and giving them something like that and also a little bit of team building on themselves".*
> "*well for me it was interesting even because I teach java so Python is totally different that way you…. The syntax so for me don't think that all, I mean I know that for loops the while and all that but now putting the spacing, putting the colon instead of semi colon all those things. It was something new even though we're familiar with the coding, you still have to learn".*

Recommendations

"One thing I would like to see is the recording of what the students did or done so that we can see from their point of view and see what they like, so basically their reaction to every lesson and their thoughts".

"even hearing the conversations I think are important too. So if you couldn't make the video maybe just the audio of the conversations because I have a lot going on in my classroom".

"*the pretty good thinking that happens at the very beginning that taking the big content and breaking it down and then working for efficiency or working for something there. Uhm so I think maybe making that much more clear for day 1 may put into perspective".*

"I think like this is the first workshop that you guys have put it on, so I think you guys kept it general enough for everybody just to get certain concepts maybe for the next workshop is bringing something in business, and in different subject matters".

"like having others plan what they could work for it their motor skills to learn having stuff like that they could use this part of the of the content knowledge even to add on to that maybe even to centers, for example to measure the ph level just that goes into your computer and just like using one sense or maybe adding more gadgets to the whole project will be nice to see".

Appendix E

Teacher sample interview results

This section includes quotes from teachers ideas in the interview, the ideas are included in terms of the themes emerged from the analysis.

Implementation in class

For example, teacher Jen mentioned she used the coding part of the workshop:

> "*even though I am not a coding teacher I think that getting out of the routine of doing the typing and doing the… the work and I thought transferring to the coding part will kind of give them interesting so we are starting coding classes computer science like [unintelligible] so I kind of want to start getting interested in that. So that is how I started with the technology".*

"so they kind of went through that and I can like show them and then can went through like the concept to the other game and they loved everything that has to with technology so they were really excited about that one. So I was pretty much like going through, we went through uhm like basic directions".

"again I do not know if the Sol y gua… and Agua program falls on to this, but I did used that, uhm… you know except we are getting to uhm… the drone part was fun, they enjoyed flying over with keys, they were… some were little higher that others when you have to control, the key pad. Others were little slower where they were getting confused which keys to… to press and all of that, uhm… some of the program aspect of it I did not, because I thought uhm… it was maybe too advanced for them, and they lose it right away".

Implementation plans

"I did not plan for it, so uh… between now and the workshop has been a short amount of time and uh… I could plan for it if I had the activities at the beginning of the school year".

" uhm… not yet just because, just because I have not tried it yet so I do not really know, I do not know necessarily like what is possible with my students".

"uhm… so I wanted to make sure that they understood like say for instance the step of identifying all the alternatives. I wanted to make sure that they fully understood that step uh… before moving on to anything else, because if not I thought that they were going to be too limited in try to find just one simple solution and not all the possible solutions so bbb uhm… I am fairly confident that I will be able to do uh… to do some of them at least uhm… but I won't really know until I do it".

"not yet, not so much… well we are just… because like I said we are focusing in the certifications and… and I do not think we have like as far as schooling and stuff we cannot incorporate that into what we are doing at the moment but I would like to maybe, before the school year is over get not that a little bit more".

"uhm… well… I mean… it was… I kind of have to like re… like is just breaking everything down, I wanted to teach them um… obviously like some other stuff but it… since they are so small Can I have to like… it is…I would need much more time to kind of like build it up for them".

"I think I would like the one with the Agua and Sol… I can… I can use that to teach them how to kind of buy and use money".

But besides her business curriculum, teacher Jen was thinking also in interdisciplinary topics, like including some geography and biology topics into her class:

> "*yes and then I like it than it also implement science and geography oriented because our principle is always asking us to kind of incorporate other subjects in to our electives and that kind of bring it all together*".

"I think the programming part, would be nice for some of the kids that were higher, uhm… more advanced and that would help them to be more focus, uhm… the program or the room we were in, unfortunately it was wide open, so anything that was happening over here is a distraction, so if it was for the room if we could had it more, or they were more isolated and in that be able to see what is going, will be desirable, that would it help I think uh… to get the more a little more further on and say program or aspect, or even the Sol y Agua program".

Workshop acknowledgement

"Honestly the one that I like the best is the one that probably the lowest tech was the one where you give instructions for robot to get upon or [unintelligible] I did that one for just one and make them get the one that to get there more quickly". "I am really excited to keep implementing it".

"I want to throw the idea of programming in some of them uhm… so at the end of the semester what I do is I do , I do group projects for all of my classes. Uhm… in where I assign them specific task and I say okay you have to figure out how to do this task".

"uhm… well yeah the python… the python, was the python, right? Uhm… was really the most helpful and probably going to be the most helpful with the project that I am going to do uhm… I… I do not know uh… in terms of the actual technology that is probably the one uh… in terms of other things like the…"

"oh… again the computational thinking and the problem solving again uhm… so far I think we are kind of already doing that in a way, but maybe more help uhm… helping them to realize how to do problem solving a little bit better to get to the solution because they get frustrated. And I am just read the directions step by step, you gotta think about it before you actually do it and… so maybe just some strategies I would…"

"yeah problem solving and how to… kind of help yourself before asking the teacher and try to figure out on your own first and you can do it instead of telling… asking me something that it could be answered on your own".

"again well this totally tights in into the certification, a lot of the stuff, they have to do certain things that… like a problem I guess, it is kind like a formula like for the right now one of my classes is doing power point so they have to push certain keys and they have… in order to complete a task on power point they have to maneuver through it and use some uhm… same thing with the word they have to do different steps so they need to know how to do one thing before moving on and that only simplify their live a little bit uhm with that so…"

"one thing that I did not existed was the website online gbd.com and we have to go to a competition and uhm… my students were going to use java but they did not have the program, the compiler in the computer… and so I was oh, you can use gbd.com".

"uhm… the activities for the… somebody was the robot and the other person was the programmer. I know I need to use something like that in the classroom, uhm… I tend to just say okay here is programming so programming and then, but… based on the questions I get from the students where they get stuck, they are not used to following… a lot of students are not used to following steps and they do not realize this have to go before that…"

Workshop acknowledgement

"I was much more aware of like everything I said because a lot of things like that have been mentioned I did it without noticing, but I never realized I could be extended more and like actually like be taught to the kids in a way that they like actually learning it and internalizing it. So, it was kind of more of… the way I worded things and… like giving them like these big words so at first like yeah, it is a little difficult because they seem very confused, but after kind of like going through them and maybe talking about them more throughout the week like they are… you hear little four year old like yeah I am using my computational thinking".

"Prior to the workshop we had already been doing a lot of the hands on activities and a lot of exploration and a lot of the think pair share that type of things I have been trained to prepare that work giving the students the chance to like think about things together first before they speak out loud and uhm… I even trade the wall on task first when they have little jobs and as much as they uhm… they really do like and then each person has a job and they do like, like so for example one person was in charge of collaborating with the teacher so I could only get questions for that person and another person was supposed to be checking work, the other person was supposed to be in addition collaborating so it was a really neat the strategy that does work and I did [unintelligible] it forces them to get out of their comfort zone…"

"uhm… in a way I did uh… uhm… because I realize we were doing computational thinking I was really sure to be a little bit more clear and helping them realize that in order to get to the next step or to lead to solve the problem or answer the question I had to break it down and take the steps so I kind of did it in a way just the way I explain myself and how uhm… I explain how to do stuff with them I realize, okay I need to break it down a little bit more so they understand it clear and they understand why they are doing what they are doing instead of just doing it. So I did, I have incorporated that into my classroom that help me to realize it".

Teacher Joe mentioned the workshop helped him to go step by step with his students and try things before using them in class:

> *"it was just kind of taking them step by step, uh… of how to go, or try how to try go about what should be happening. Uh… as far as coming up with anything unusual or different I want to say I did not".*

"uhm [deep breath]it made me want to stop and review everything uh… because I do feel there is a place… so another thing that really impacted me, was taking the data and having the… and having us identify what kind of data it is… the Boolean, integer uhm… because that get to another thing that I just rely on the computer science students having, also being good at math, so that I do not have to go back over that, but that is something that has helped me in case of the student is not that good at math or has trouble, uhm… so they can practice identifying the variables types, because again that is something I… I speed through when I teach and I just say here is, do it".

"*now I am getting them a question back or being forced to think themselves and I think that is one of the hardest things about students who are in seventh grade is that they come from elementary school and they have a lot of different experiences when they come very strongly saying already I do not like math, I am not good in math, I am not going to be good at it".*

"So it is a lot of train to bring that mind shift and a lot of also they were used to being asked what to do and how to do it, and this what I want for today and this is what I want you to do, so in seventh grade is kind of a little bit of breaking that, because is like now you must to think for yourself, now you have to tell me a way that make sense to you".

"yeah and I also tell them like okay we are going to do this uhm… today but you need to understand why you are doing what you are doing I do not just want to push this button and move on to the next step you need the why and you need to make sense too okay that is why I am going to break it down is smaller steps and, it helped me".

"Honestly it was…it is really… it is really helpful for me because uhm… I mean it has been two years but it is not a lot of time that I have been teaching so I am still a lot and I am still not sure how to uhm… kind of like sometimes I had to re learn things so that I know how to teach them to them again because since I already know it, it is kind of hard for me that like to put myself in their position like I do not know understand, so having like seen I am a really visual learner so seen like in a paper like the steps of how like go back and re trace my steps was really really helpful for me because… they go at things that I learned before like I did not really learning I learn it from for the moment I need it and then it kind of went off but like having kind of like the reference of how can get the kids to actually learn things for to stay and not just for that second that they need it were very helpful for me. Also to like my own background, like how am I going to re learn things actually have them stay in like my memory I guess to… I really…it was really helpful for me and I liked it".

"I would like to think it made it better uhm… I mean based on this on some of the stuff that I sent you, there is a big difference in […] they were just try to get the work done just to get the work done, and now is actually helping me developing better as a college students is not just, they are high school freshmen but I have to get them ready to be college students".

"for some of the examples that uhm… some of the other teachers were giving, it opened my eyes to… maybe use some of their techniques that were, that were, uhm… that they were using for as far as using in the classroom. Uh… as far as the details I cannot remember exactly, but there was one lady who was coming up with what she was trying to do and use for her classroom uhm… the only thing that was pro… my problem was that it was a… I think a different set of students".

Participant's context

"it was really great, I liked that we had the time to uhm try out different strategies that we were kind of like the students make out strategies on our own and see how they worked like me for the most part it was a really good environment for almost for everybody there even if you know each other you came from different campuses I was the only one form my school and like being able to connect with people and I thought that was really really cool. I liked a lot".

"oh I thought it was very helpful and useful and I just think that more teachers just need to be aware of it, and it would be great if you have more teachers involved or to attend the workshop having to review that that would be… they realize sometimes you need that way to call let them know oh yeah, I am doing that already or oh okay I can incorporate this into my classroom I think".

"uhm… it was just really nice seen like other teachers like having like the I guess not problems but some of the issues they had even though it was like high school teachers were so like interconnected like I had similar pro… like problems with the kids like oh they get distracted so you cannot always… so there is just all around and uhm… it was nice seeing that like there is different ways to like get their attention now that… I guess it gets a little harder because they are always like I should do that and I should do this and having ways of kind of get them back to being interested in like in going outside and do more things with… but we are still teaching without even they noticing I think that was… I do not know that was really me like I found it really me because anything that I can find for the little to keep them engaged is like a big thing because like five minutes for them is like the longest time. So, yeah I do not know it was really rewarding for me".

Content knowledge

Implementation in class

"oh, well for like it was pretty much like the problem solving that we did talk about and uhm… we used it in more than just the…like I guess like the problem solving and went into like everything kind of…like we were having trouble with them because they have to wash their hands with water and they use a lot of water and use a lot of soap because they just like playing with the bubbles and stuff, so I kind of went back and brought those vocabulary words and put them into like, how can we problem solve that you guys are… [laughs]using way too much water or too much soap then if just bringing like relevance to like the word so every time I would be like how do you solve the problem that…oh like when we did it with the soap and water… it was just kind of like a background for them, it is a really simple things for them to like for to really long way".

"uhm… I think…rather than modify it was like my notes nor like kind of like wh… I always try to go through it because you have to be so prepared for like them… with them at least like they have so much props that they need and so much things they need to see for to be engaged, so just having that kind of like the script for me like to know when I have the opportunity to like bringing in or when I could. That way I wouldn`t miss like a, I guess like the chance like to bring that in to them".

"yes the chapter the general problem solving concepts that is the one that used"

"going back to the multidisciplinary thing I went back to the… the gaming, and I have to look, search the water intake for us. I do not think they have the knowledge of how much water we have, and how much water they use and I am trying to plan a trip like towards the end of May to the water uh… take each tool so they can see the space there and they can see uh… the geographic part of it. They are doing research on that right now, that is one of their projects that they are doing within the so they are working on that and they have to do the drawings, the water use".

Teacher Joe mentioned that he used the algorithms topic in his class to try to get students to think in different ways, and kind of giving them steps to do it:

> *"okay, so the algorithms pretty much yes, uhm… trying to get kids like doing the robotic uh… exercise, so just trying to get them through to the programmatic algorithmic thinking trying, trying to get them into that thinking of saying what is the next step and does it make sense, uhm… for the problem solving skills is like, if they did something if the next step was not correct, then I try to go and tell them why is not or… I tell them that was wrong or I say why did not you go this other way or why is this a better way or doing it. So, I used some of the problem solving skills, uhm… in those aspects".*

Implementation plans

"I plan on using them, so right now we are at the interesting point in time of the year where we are getting ready to STAR test so for right now with my advance class I am planning after STAR testing to start some of the programs with them and then for after STAR for my regular math class I do want to implement it too but is one of those things that we have to wait, yeah we have to do all the review all the content first and then uhm… we can do that"

"I mean I would love to incorporate as much as possible uhm… again I think the problem solving I think is the biggest thing for me and learning how to… better solve the problems whether is a simple math problem or even to learning how to use a specific software. How to practice how to problem solve, so I would like to be focus on that a little bit more after the certification".

"all of them [laughs] I would like to incorporate all of it because again it is all of it is part of the curriculum for computer science uhm… but again I believe that the computer science can be included in every class".

"so for the advance math students they test at the beginning of April so we have the rest of April, May and the first week of June. And then, for the regular math students, they test a little bit later so for them it is probably about a month, a month".

Recommendations

"uhm…no I mean it just that…. And I know that there are other teachers that you were saying from a reading or teaching reading or something like that, so it just seem like the classroom of course I do not know if there is yet there but it seem like the workshop was of course programming, robotic, algorithm, and stuff like that. Not technologically, but maybe trying to use whatever computational thinking into uhm… I say the reading or an English"

Appendix F

Sue and Emilia: an ideal implementation

Technological knowledge

"*Emilia: And then I told them, the… the actual uhm… program or the coding has to be very specific and has to be short, so then they were kind of like oh we could it say three times step forward so they were trying to you know conclude and see, uhm… what different types of… that they can use because they knew they were limited and at the end I told them okay we wanted to add another command, what can we add and… so they were very specific they got into it and they were very excited".*

Emilia: "yeah because, I think I did it first and then when I went and told miss Sue and then like, you know is like you are teaching the first time and you are like man I should done this and that, so when I bounced the ideas of her, she is like okay she kind of have more of an idea or like the misconceptions that kids have and you know, things that I missed that I could said so when, because we did it uhm, one full day so, I did write down notes so that way I could be specific with those you know misconceptions that I could not address when we get started, so…"

Sue: *"I did use python 3, one of the sort of real blocks that I had with the kids was the alignment, I know that it is supposed to naturally just kind of aligned for you, but if anything was you know space wise, slightly off, then of course the program would not run properly and sometimes the kids get frustrated. But I thought that was even good too, if they got frustrated…"*

Sue: *"Well it is because you indented too far here, or it is because you left a space. I told them, look at what I give you again, does yours match mine? Go though it line by line, and you will find what the issue is. [deep breath] So, I think there was an appreciation now, because they did all this code for it to tell like you know "Hello world" you know and, so I told them okay well that what goes into everything you are using".*

Emilia: *"and because that we are focusing on the seventh grade advanced of the PAP I guess their minds they are just so fresh, so new, so when we introduces them something new and it is something that is technology and then the coding and then different, I mean it makes it… you know, easier for us because they are, they want to learn.*

Sue: *"I just started a STEM festival this past week and we were able to… we saw over eight-hundred people and we were doing also pots and spyros and… I mean they were eighteen month old babies who wanted to go and play with them, so you were actually right miss Emilia in we are getting them at the right time".*

Emilia: *"and with these topics kids we have to keep their interest, because all we are doing right now is… it is sad to say that we are just showing them the test, and we are going over it, right now we are doing STAR blitz, so that is a little like kind of repetitive for them because they do not need that, they need to be challenged"*

Sue: *"there is time period when we finish our testing but the school year is not up, we have a few weeks left. It might me really neat to incorporate some of this even if we could do Sol y Agua to that time period"*.

Pedagogical Knowledge

Emilia: *"And actually like writing it down, helped and then us analyzing it and then say how can we do this different, so even though sometimes I am like well I do that but I actually do not literally sit down and actually so what I… because of that uhm… I do a lot of like my sitting arrangements and I do… usually I already kind of like know and I just do it like, for in the moment, but now, because of that I am like, no let me think about this, I wrote it down, wrote down, look at the, the roster and I kind of group them and actually put a little thought into it and actually like… actually if you go to my class, I mean I actually work with the classroom management, because they are on task, I changed them with different groups, but I just put a little more effort in my, you know seating, you know, my groups, my small groups, and really analyze it and before the workshop I thought I was doing that, because you know I am just like, I have been teaching for this long I think that I already know but we have to go back and we have to like actually take the time and plan".*

Sue: *"it made me appreciate that my students background in what we are going over may also be different. I may have those students who know a little bit more going into the topic, and I might have those who are really coming from a place of not knowing anything, so it made me a little more sensitive, in starting everybody at the same point, and just a very basic level and then those people who know a little bit extra, they can help the ones who maybe are struggling so that help me sort of be more sensitive to those groups uhm… it also helped me because we were not working with the same group each day and it remind it me that yes it is important for us to get out kids out of their comfort zone, a little bit shake it up, and make them work with people that they do not normally work with…"*

Emilia: *"like miss Sue said I think it just made us more mindful, more aware into actually use the strategies that were taught, like for example the classroom management, also uhm… you know just doing, you know introducing like… like she did the Phyton, and like… the workshop being modeled is kind of like you know helped us, you know, know what we need it to do and how to teach it, and so yes definitely using the strategies that we used in the workshop".*

Sue: *"I think, when you are teaching then and day out you forget sometimes what is like to be the student, and in that workshop we were the students…and so being able to see how teaching goes from that perspective was really important, there were certain parts of the workshop that I felt were too fast, and we went through them maybe too quickly and I would of like them to be slow down for example with the coding, I… because we do not have a background…"*

Emilia: *"I just think like miss Sue said I know was two days and it was crunched on time but, I would it like to be a little bit more slow and explain a little bit more the coding because I did not have that background and I did meet a lot of teachers there that had some background and then I met some that did not have any idea so like there were all at a different level so it would it nice because at the first what is a string or you do this and I was like okay [laughs] so you know it was*

assumed that we knew and it would been nice or at least to have in the pocket like the rules or like the coding".

Content knowledge

Sue: "uh… for me you know it has affecting my lesson planning in that you know I would not have known to do Otto the robot with them, I would not have known how to introduce coding, and I thought that was a really clever way to introduce it, uhm… I just never would come up with that on my own, so it did modify my lesson plans there, and of course after testing I am sure we know towards end of the day miss Emilia and I would have many more conversations uhm… about maybe what we can do collaboratively with our groups and, so we are looking forward to that".

Emilia: *"I mean the computational thinking and…. Talking about again the coding, the algorithm that was when I introduce right before I was let them know what our… what they are going to be… you know seeing after STAR and learning, so I uhm… have not done it like on the day to day, uhm… basis with them but I ha… but I did introduce the computational thinking and…"*

"*yes, we actually I mean, I modified the lesson just to introduce them to the idea that we are going to be… they are going to be seen, so uhm…right now it is just kind of like it will because we are just doing the STAR blitz, but uhm after the STAR then that is when, we are actually like right now that I already have like that one lesson as far as what are going to be doing like the… being specific if you were to like look for a flight, or you are going to put it up the internet, so that will be, that is already one lesson that I have already uhm… you now modifying and then I am just going to continue off on that".*

"*no I actually uhm… I just want to say that because of this workshop I am able to introduce something new this year to the kids, and challenge them, and have them do that critical thinking. Because I think we do not do that enough in the class uhm… especially we have to worry about STAR is just very tedious so, just keeping like this you know, STEM activities, ideas and implement them maybe next year that we… This is like a trial it is the first time, so now… well at the end of all this, when we start doing maybe the programming the coding, maybe next year we can implement it maybe earlier in the year.*

Vita

Diana M. Camberos earned her Bachelor of Design degree in graphic design from Universidad Autónoma de Ciudad Juarez in 2008. In 2013, she received her Master of Education degree in teaching and learning process in Universidad Virtual del Tecnológico de Monterrey. She joined the Doctoral Program in Teaching, Learning, and Culture at The University of Texas at El Paso in 2015.

Dr. Camberos was recipient of the Chihuahua Government scholarship. She has presented her research at international meetings including the 2018 International Conference on Creativity, STEAM, and Marker Education in Taiwan, and at the 2018 I Congreso Iberoamericano de Docentes in Algeciras, Spain. Her work has appeared in the proceedings of these conferences as well as the Journal of Latinos and Education.

While pursuing her degree, Dr. Camberos worked as a research assistant for the Department of Education in collaboration with the Department of Mathematics.

Dr. Camberos' dissertation, "Analyzing Teachers' Technological Pedagogical and Content Knowledge" was supervised by Dr. William Robertson.

Dr. Camberos has an interest to continue working in education research after the completion of her doctoral degree.

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