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Abstract

This research aimed to investigate and compare teachers' conceptualizations of their students' and their own outcomes of our earlySTEM program at the K4 level in two distinct roles: practitioners only and practitioners and program developers jointly. The study group included 66 teachers, 26 of whom had actively contributed to the development of the earlySTEM program. Teachers in both roles were supported by teacher guides, student books and workshops throughout the 8-month long academic year. Data was collected at the end of the academic year through an open-ended survey. The program developer teachers identified more student outcomes under more diverse categories while the practitioner teachers mainly concentrated on cognitive outcomes and limited their conceptualizations to the national curriculum. In addition, the program developer teachers valued their involvement in the program development process and expressed more diverse professional outcomes referring to different types of teacher knowledge.

Introduction

The promotion of STEM education is a common agenda in most countries in order to increase the number of students interested in STEM subjects and their likelihood of pursuing careers in STEM fields (Oner & Capraro, 2016). The development of student innovation, technology, and scientific literacy skills through STEM education is a key policy objective for many countries (Baran, Canbazoglu-Bilici, Mesutoğlu, & Ocak, 2016; National Academy of Sciences, 2006; National Academy of Engineering, 2009; National Research Council, 2012). A substantial effort is needed to encourage both teachers and students to engage in STEM-based activities (Han, Capraro, & Capraro, 2014). Several studies suggested that early exposure to STEM education had positive effects on self-confidence and gives elementary school students a long-lasting interest in STEM subjects (Bybee & Fuchs, 2006; Daugherty et al., 2014; DeJarnette, 2012).

Some researchers believed that elementary classrooms were ideal settings to implement integrated STEM education because there was relatively more flexibility in the elementary curriculum compared to middle or high school curricula (Nadelson, Seifert, Moll, & Coats, 2012). This flexibility in the curriculum was naturally extended to independence in instructional practices of a single teacher teaching most of the subjects (Toma & Greca, 2018). Yet, it was not uncalled for teachers to not have any critical roles in determining the frequency and quality of STEM education implementation in their classrooms (Nadelson et al., 2012). Aligned to this argument was that students' STEM education experiences were strongly influenced by how their teachers conceptualized and taught the content (Diefes-Dux, 2014). However, several studies consistently, across the years and contexts highlighted a lack of content knowledge and low self-efficacy beliefs of teachers (Brophy, Klein, Portsmore, & Rodgers, 2008; Cakiroglu, Cakiroglu, & Boone, 2005; Calli, 2015; Enoch & Riggs, 1990; Ersoy, 2018; Espata & Tank, 2017). Moreover, teachers reported a need for in-service training in STEM education, as well as better resources and more preparation and lesson development time (Nadelson et al., 2012; Wang, Moore, Roehrig, & Park, 2011).

This study examined elementary school and preschool teachers' conceptualizations of their students' (aged 5-10) and their own outcomes when they had roles as practitioners and when they were acting as both practitioners and program developers. During this investigation, the researchers started by exploring the challenges faced by teachers in integrating STEM disciplines into elementary and preschool classrooms, following the need to examine the impact of the earlySTEM program on teachers' knowledge and practices as well as their student outcomes.

Conceptual Framework

STEM Education & Student Outcomes

There is a consensus in the literature that STEM education should be implemented as early as elementary (grades 1 to 4) school level (Brenner, 2009; Dejarnette, 2012; Daugherty et al., 2014; Walker, 2012). Some researchers found benefits of starting at kindergarten level (Gonzalez, 2016; Toran, Aydın, & Etguer, 2019). Daugherty and colleagues (2014) emphasized children's innate interest in STEM although there were fewer opportunities for STEM exposure at elementary classrooms compared to middle and high school classrooms (Dejarnette, 2012).

At kindergarten level, there is a limited number of studies focused on school readiness and concept acquisition on STEM fields. For instance, in a recent study researchers found out statistically significant gains in school readiness and concept acquisition scores of the experimental group after implementing STEM activities in a nine-week period (Toran et al., 2019). Ocal (2018) concentrated on effects of STEM activities to the development of science process skills and ended up with significant differences in favor of the experimental group. Solis, Curtis, and Hayes-Messinger (2017) incorporated play in their research design and observed children using some STEM concepts during their games and they were able to associate these concepts and use them in their solutions to the problems encountered during the games.

STEM literacy was defined as using conceptual knowledge and procedural skills of STEM disciplines to solve problems at various levels as personal, local, and global (Bybee, 2010). Thomasian (2011) acknowledged the importance of transferable skills across STEM disciplines such as critical thinking for understanding a problem, using individual STEM disciplines to deepen the problem, and choosing the applicable steps to work on the problem.

Considering the development of STEM literacy of students, some researchers claimed that STEM education research should focus more on student outcomes especially with long-term studies (English, 2016). Interdisciplinarity and representation of each STEM discipline should be key features however, some other researchers pointed out that mathematics was relatively invisible in most of the developed STEM programs (Shaughnessy, 2013). Apart from the cognitive outcomes, affective outcomes came forward such as teamwork and communication skills in the meta-analyses of STEM/STEAM education research (Kang, 2019). Estapa and Tank (2017) studied with elementary teachers and examined the changes in their teaching strategies after participating in a STEM professional development (PD) program. Their study had a reference to student outcomes because they found out that teachers had still difficulty in integrating science and mathematics but they tended to focus on the development of practical skills and included more teamwork and inquiry-based teaching strategies.

Regarding, the link between student outcomes and teacher preparation, STEM education literature lacked research about STEM teacher preparation (Brown, 2012; Rockland et al., 2010; Wang et al., 2011) especially at elementary level (Rinke, Gladstone-Brown, Kinlaw, & Cappiello, 2016). Although several countries adapted their education systems according to ongoing technological advancement and scientific inquiries by integrating STEM in their curricula, these adaptations still did not match with their initial and in-service teacher training programs. Driel, Beijaard, and Verloop (2001) criticized that general education reforms were presented in a top-down approach in which teachers, students, and their classroom environment were not prioritized with respect to national goals. Rather than a top-down approach, researchers claimed that more studies were needed on teachers as practitioners to reveal their views about STEM practices and integration (Wang et al., 2011).

To challenge teachers' beliefs about STEM education, programs that involve teachers as active agents throughout the curriculum development and implementation processes are a primary need. Our previous research showed that teachers, who held active roles as designers, collaborators, and learners, could make sustainable interconnections between math and science content and between the methods used in these disciplines (Asik, Doganca-Kucuk, Helvaci, Corlu, 2017; Corlu, Capraro, & Capraro, 2014; Keskin, Corlu, & Ayas, 2018).

STEM Education & Teacher Outcomes

Professional development (PD) activities for STEM education were found to be critical for implementing rigorous integrated activities in classroom settings (Corlu, Capraro, & Capraro, 2014). Teachers' preferences in STEM education environments might be affected by their earlier preparations of STEM applications (Nadelson & Nadelson, 2010; Jesky-Smith, 2002; Plourde, 2002). Teachers' professional preparation, in this sense, was essential to achieve the high level outcomes expected from students (Nadelson et al., 2013). The student outcomes resulting from various STEM teacher PD studies pointed out differential effects depending on the specific features of the PD that teachers participated in (Capraro et al., 2016). From this point, it became important to systematically inquire teachers' knowledge, skills, and attitudes on STEM teaching practices to gain evidence on how teachers' develop their knowledge and transfer their gains in their STEM teaching (Corlu, et. al., 2014; Hsu, Purzer, & Cardella, 2011).

Professional development of teachers made integrated STEM education experience accessible in classroom settings. However, omnipresence of different approaches to STEM education could be challenging for teachers and educators (Baker-Doyle & Yoon, 2011). Hence, how STEM education was conceptualized and disseminated was found to be critical (Oner & Capraro, 2016) and therefore an integrated teacher education was needed for producing higher student learning outcomes (Czerniak, Weber, Sandman, & Ahern, 1999; Frykholm & Glasson, 2005; McBride & Silverman, 1991).

In line with the shift from disparate teaching of STEM subjects to focusing on themes or big ideas, integrated teacher education equipped teachers with knowledge, skills, and beliefs necessary to bring out creative and innovative skills from their students (Cuadro & Moreno, 2005; National Research Council, 2011). An integrated approach to STEM education required teachers to develop a system perspective and broad content knowledge to grasp STEM as an interconnected entity with a strong relevance to life (Tschannen-Moran & McMaster, 2009). As a useful model, the integrated STEM approach also made teachers more flexible to changes in their teaching practice that empower teachers to improve students' learning (Capraro et al., 2016; Levitt, 2002).

The present literature regarding the effects of teacher PD on student achievement outcomes indicated that the impacts depended on the quality and the specific features of the PD provided. The findings indicated that high-quality sustained teacher PD typically had positive impacts on teaching practices and student outcomes (Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Yoon, 2009; Nadelson et al., 2013; Supovitz & Turner, 2000; Wei, Darling-Hammond, & Adamson, 2010; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Although research findings underlined the importance of teachers for effective STEM education, little voice was given to teachers for both developing and implementing STEM policies and STEM curricula (National Academies of Sciences, Engineering, and Medicine, 2017). In this manner, PD activities generally missed the involvement of teachers in the program development process.

Teacher Involvement in Program Development

Curriculum development was defined as an endeavor to structure teaching-learning experiences in a learning environment. The involvement of different stakeholders in the curriculum writing process can change with respect to educational policy and philosophy across nations. According to top-down policies across nations, teachers were perceived as passive implementers of curricula. Thus, any teacher involvement in the development process was not expected or simply discouraged (Atkin & Black, 2007). Expectedly, these top-down approaches resulted in teachers' resistance to implement the curriculum, on which they had no voice, or involvement. For effective implementation, teachers' dual roles of program developer and implementer began to be recognized (Kelly, 1999; Penuel & Gallagher, 2009; Pinto, 2005; Prawat, 1993).

Teachers' involvement in curriculum design process was regarded valuable especially for innovative reform curriculum movements, because teachers' ownership and commitment were required for a curriculum reform (Ben-Chaim, Joffe, & Zoller, 1994; Hargreaves & Fullan, 1992; Voogt, Pieters, & Handelzalts, 2016). In the Turkish context, there was a top-down approach in curriculum development (Demirel, 1992; Yüksel, 2003; Suat, Costu, & Karakas, 2004), however more research studies have been carried out to empower teachers as program developers (Haciomeroglu, 2018; Ozgen, 2019; Toprak, Ugurel, & Tuncer, 2014; Yurtseven & Altun, 2018). Empowering teachers' role as curriculum designers is critical for reducing theory/practice discrepancy and for the success of innovative curriculum reforms.

It is widely accepted that teachers' involvement in the curriculum design process was crucial for the ownership and successful implementation of the curriculum. How to integrate teachers' design ideas into the curriculum was also discussed in the literature. A balance was needed between too much and too little direction, as Pinto (2005) noted *"Give(n) too much direction, teachers lose any sense of ownership. Give(n) too little, and they feel that they do not know what to do."* (p.2). Researchers acknowledged that curriculum design required expertise and teachers need support during the curriculum design process (Forbes, 2009; Huizinga, 2009; Nieveen & Van der Hoeven, 2011). McFadden & Roehrig (2017) indicated that a balanced approach between involving and supporting teachers in the curriculum design process facilitates the inclusion of teachers' detailed knowledge of the classroom into the curriculum in a generalized way.

Providing PD activities via curriculum development comes forth as a balanced model. Integrating curriculum development into professional development has the potential to establish an interactive learning environment for teachers. In this learning environment where teachers' practices were the focus, both the curriculum was designed and teacher learning was provided through the scaffolds by the experts (Clarke & Hollingsworth, 2002; Garet et al., 2001; Putnam &Borko, 2000; Shawer, Gilmore & Banks-Joseph, 2008). When teachers collaboratively worked on a design task with the supervision of a facilitator, this professional learning community could *"share knowledge, exchange perspectives and tap into each other's expertise*" (Voogt et al., 2016, p.62). In this interdependent learning environment, a participatory and powerful relationship developed between teachers (Remillard, 2005).

In the Turkish context, the conventional in-service training is based on traditional teacher learning methods and efforts involving teachers in program design are limited in number (Demirel, 1992; Yüksel, 2003; Suat et.al., 2004). Therefore, it is critical to understand teachers' learning processes in PD activities where teacher involvement in the program design is embedded. Within a STEM-integrated curriculum, it was particularly important to create a balanced model (McFadden & Roehrig, 2017), because teachers had to find ways to integrate disciplines and create challenging and rigorous real-world problems. In this way, teachers also had a sense of ownership of the program they took part in and showed an effort to implement the plans to enrich students' learning experiences.

Following the previous studies on effective STEM education and STEM PD, this study focused on student and teacher outcomes resulting from the implementation of the earlySTEM program. The purpose of the research is to explore the difference of the conceptualizations of two groups of teachers: (1) teachers with a single role as practitioners and (2) teachers with dual roles as program developers and practitioners. The research was centered on the following research questions:

1. How do program developer teachers and practitioner teachers conceptualize student outcomes in the earlySTEM program?
2. How do program developer teachers and practitioner teachers conceptualize teacher outcomes in the earlySTEM program?

Methodology

Research Design

A qualitative research methodology was used to gain insight into the conceptualizations of teachers with different roles in the earlySTEM program about students' and their own professional outcomes. We reviewed conceptualizations of teachers towards students' and their own outcomes in the earlySTEM program as the central phenomenon requiring exploration and understanding. The method used for the current study was the phenomenological study that is to *"get the basic underlying structure of the meaning of an experience*" (Merriam & Tisdell, 2016, p. 27). Through the phenomenological study, we aimed to learn from the participant teachers' lived experiences within the implementation of the earlySTEM program and their experiences in two different roles as either practitioner or program developer and practitioner.

Study Group

Sample of the current study consisted of two groups of teachers implementing the earlySTEM program in Turkey. One group of teachers (practitioners) only implemented the program in classroom settings, while the other group (program developers) contributed to the development of the earlySTEM program by meeting regularly with the program development team (teachers and academicians) and designing the earlySTEM lesson plans in addition to the implementation of the program. The latter group of teachers was determined and recommended by the school administrations to take part in the program development process. In further sections, we will refer to the first group of teachers as "practitioners" and the second as "program developers" considering their contribution to the earlySTEM program.

In this study, all teachers, both practitioners and program developers, were asked to fill out an online survey voluntarily. The survey was sent to teachers via an online platform and the researchers ended up with almost a fifty percent response rate (66 out of 130). A total of 66 primary and preschool teachers on several campuses of a private school located in different cities participated. Approximately 60% of them were the practitioner teachers (*n*=40) with an average of 13 years of teaching experience. While the rest played an active role in the program development as well as implementing the earlySTEM program (n=26) and their average of teaching experience was 18.7 years. The demographics for teachers in terms of their involvement are presented in Table 1.

Table 1. Demographics of the Teachers, by Teacher Involvement

		Program developer teachers	Practitioner teachers
Gender	Female	21	29
	Male	5	11
Degree Completed	Bachelor	22	38
	Master's	3	2
	Preschool	9	4
Grade Level	1st	4	12
	2nd	8	3
	3rd	1	12
	4th	4	9

The earlySTEM Program and Teacher Involvement in the Development Process and Implementation

The earlySTEM Program

The earlySTEM program has been implemented for five years in an increasing number of elementary schools in 56 different cities in Turkey. The program targets K-4 students and they have one earlySTEM class hour each week throughout the year. The program includes four different themes centering one S-T-E-M field in each theme and student group projects are presented at the end of each theme.

The program is structured on the STEM: Integrated Teaching Framework (see Figure 1) developed by Corlu (2017). The framework was modified for primary level with a thematic approach to work on various problems under a theme with integration of at least two STEM disciplines as also suggested by Bybee (2010) and Zollman (2012). As seen in Figure 1, "Authentic problem of knowledge society" (APoKS) is placed at the center of the framework. APoKS is presented as an open-ended problem with a scenario specific for 21st century conditions and it should be solved by developing authentic strategies and products considering the limitations of the problem by students (Asik et. al., 2017; Capraro & Slough, 2013; Corlu et. al., 2014).

In the framework, each STEM discipline plays a central role in the corresponding theme displayed in the figure but the dashed lines indicate integration of the other STEM disciplines in the themes. The themes are surrounded by the principles of the framework. Developing a knowledge society is the prominent principle for the earlySTEM Program while the overarching STEM education objectives are presented at the outer layer of the framework.

Figure 1. Integrated Teaching Framework for earlySTEM program

Teacher Involvement in the earlySTEM Development Process and Implementation

In 2016, the development process of the earlySTEM program was initiated with the leadership of the two of the researchers. 24 classroom and preschool teachers and two administrators selected by school administrators from ten different schools came together to discuss philosophy of STEM education, various examples of APoKSs and implementations. For the first year of the earlySTEM program, the content was developed by the two academicians but the program developer teachers worked on lesson planning and differentiation among the grade levels.

The program developer teachers and academicians gathered twice a year at a university environment. Each gathering took two days. The first half day was devoted to introducing and discussing the earlySTEM theoretical and conceptual framework, STEM education approach, the Integrated Teaching Framework by discussing each component, and discussing available resources, classroom and school environments, and any possible support to implement the earlySTEM Program. Teachers spent two half-day periods to learn about the content of the two earlySTEM themes by being involved in the learning tasks actively as students. After their active involvement with the earlySTEM themes, they designed lesson plans for kindergarten to 4th grades to teach each earlySTEM theme in an eight-week period. They met a second time during the academic year to give feedback and discuss the two earlySTEM themes that were implemented at schools and to work on the coming two earlySTEM themes for the rest of the year. The content of the program was revised each year based on teacher feedback to equip students with enriched STEM experiences at different grade levels.

The program developer teachers in active roles improved the earlySTEM program by designing earlySTEM lesson plans based on the STEMCycline (Figure 2). The STEM Cyline is a scheme to support teachers to prepare their plans considering the same planning stages and cognitive processes and it was developed within the Integrated Teaching Framework. Furthermore, the STEM Cycline intends to guide teachers to implement earlySTEM lessons in a more inquiry-based fashion where students do their own research, generate their ideas in a collaborative group work, and develop their products and test them regarding the limitations presented with the APoKS (Doganca Kucuk, 2017). In the context of 21st Century skills, teachers should consider the development of social skills such as collaborative skills, presenting one's own work, arguing based on evidence and research findings as indicated in the last three stages of the STEM Cycline.

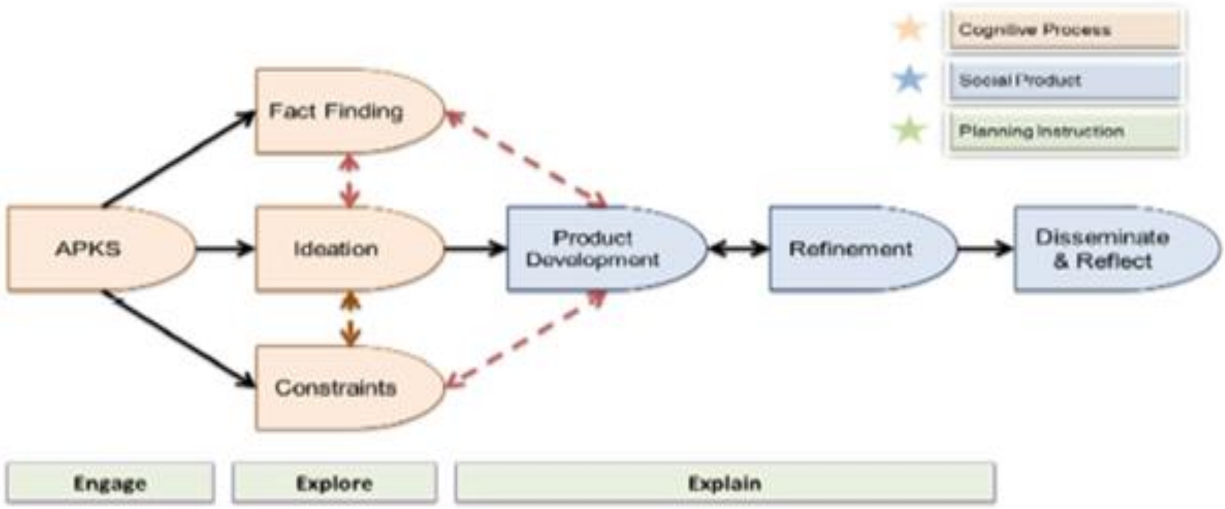

Figure 2. STEM Cycline to Represent Planning Stages, Cognitive Products, and Social Products

Apart from the program developer teachers, all teachers were expected to implement the earlySTEM program at the assigned schools. So, there was a need to develop support mechanisms for all the practitioner teachers. When designing the earlySTEM program, the first intention was to develop teacher booklets to support STEM teaching at the classes. Based on the feedback from the teachers and administrators, the following components were included:

- Student workbooks
- Storybooks to introduce the APKS, materials listed in the limitations, and possible ideas
- Teacher booklets
- Teacher workshops by the program developer teachers
- Teacher meetings of the leader teachers to monitor progress and needs throughout the themes.

Data Collection

To work on the research questions, an open-ended survey was implemented to the teachers at the end of the third quarter (after completing "My Technological World" theme) in the 2016-2017 academic year. The survey consisted of three sections: (1) demographic information (2) student outcomes, and (3) teacher outcomes. In the first section, teachers gave information about their teaching experience, age, the grade level they were teaching currently, and their educational background. In the student outcomes section, teachers were asked to report their experiences and observations about their students' outcomes after the implementation of the earlySTEM program. The questions in this section allowed teachers to explain their opinions in three dimensions: mathematics outcomes, science outcomes, and life skills. In the third section, teachers reported their professional outcomes about their mathematics and science teaching skills and social aspects of their experience.

Data Analysis

We used the participant responses to the open-ended survey as data for this study. We began the data analysis with initial coding that aimed to catalog every idea the participants expressed by identifying meaningful units of data that had the potential to answer our research questions (Charmaz, 2006; Merriam & Tisdell, 2016). We read the participants' responses, identified each section of text that communicated a distinct idea or ideas, and assigned code(s) that captured these ideas (Birks & Mills, 2011). To identify the units, we tried to meet two criteria that *"the unit should reveal information relevant to the study and stimulate the reader to think beyond the particular bit of information"* and "*it should be interpretable in the absence of any additional information other than a broad understanding of the context in which the inquiry is carried out."* (Lincoln & Guba, 1985). We followed a step-by-step process of data analysis as category construction, sorting categories and data, naming the categories, and revising the categories to become more theoretical (Merriam & Tisdell, 2016). In this process, we discussed every coding until we reached consensus, by this way, the analyses continued in an iterative and collaborative manner.

We presented the results of our analyses based on the different roles of teachers. In other words, we reported the findings separately for teachers who participated in the program development workshops (program developers) and teachers that did not participate in the program development but implemented the program with their students (practitioners). To formulate the codes, we used a combination of pre-determined and emerging codes (Creswell, 2009). For prior determination of the codes, we used the work of Ball, Thames, & Phelps (2008) for pedagogical content knowledge and STEM: Integrated Teaching Framework (Corlu, 2017) for knowledge of content and teaching section. To determine the codes about the perceived impact of the involvement in the program we used the study of Garet et al. (2001) as a reference.

Trustworthiness

In this qualitative study, to address the reliability and the validity of the data, we used the trustworthiness concept of Lincoln and Guba (1985). The elements employed for the trustworthiness of the data are prolonged relationship with the participants and data, peer debriefing, member check, and researcher reflexivity. Researchers established a prolonged relationship with the participants due to the long duration of the earlySTEM program development and implementation process. The program development and the implementation program lasted two academic years allowing the researchers to reflect on the participants' responses in terms of their consistency. Peer debriefing is getting audit and supervision from an expert. A peer-debriefer must be *"someone who is in every sense the inquirer's peer, someone who knows a great deal about the substantive area of the inquiry and the methodological issues"* (Lincoln & Guba, 1985, p. 308). We discussed with the peer debriefer about our research methodology and the findings resulted from our data analysis. Another element was the member check to ensure the credibility, dependability and confirmability of the research. After the data collection and analysis, we contacted the participants and shared our initial findings with the participants. The participants agreed on the categories that emerge on teachers' and students' outcomes. One researcher kept a reflective journal throughout the research meetings including detailed notes about the data collection, analysis, and the stages of the manuscript writing process.

The personal information of the participants was kept confidential. To be more precise, participants' names and identity information were not revealed. Before participating in the study, the participants were provided information about the process including details of research, data collection, and confidentiality.

Results

As part of this research, we explored the ways in which teachers conceptualize their students' and their personal gains as a result of program development and/or implementation of the earlySTEM program. The results are presented in the corresponding order.

Research Question 1: How do program developer teachers and practitioner teachers conceptualize student outcomes in the earlySTEM program?

Mathematics Outcomes

The participants were asked about which mathematical outcomes students gained at the end of their implementation of the earlySTEM program. Their responses were classified within three main categories: outcomes focusing on contents/learning areas, mathematical processes and attitudes. For the categories of outcomes focused on contents/learning areas and mathematical processes, content and process standards suggested by NCTM (2000) were used as a guide. Codes and the corresponding categories are provided in Table 2.

Among the program developer teachers' responses on the mathematics outcomes of the earlySTEM program, one category was outcomes focusing on students' improvement in a certain mathematical learning area. The teachers tried to evaluate their students' mathematical outcomes through their advancement in the certain strands of content that students should learn. They matched their students' mathematical gains with four out of five learning areas emphasized by NCTM (2000). As seen in Table 2, while geometry, algebra and measurement were mathematical topics mostly mentioned, data analysis and probability were never remarked by the teachers. It is not an unexpected result for both groups of teachers, because mathematics-based themes in the earlySTEM program are mainly built on these four mathematical topics.

Table 2. Categories and Codes on Mathematical Outcomes by Teacher Roles

Category	Codes	Program developer teachers		Practitioner teachers		Total	
		f	%	f	%	f	%
Content / learning areas	Geometry	3	11.5	13	32.5	16	24.2
	Measurement	6	23.1	9	22.5	15	22.5
	Algebra	4	15.4	10	25	14	21.2
	Number & Operations	2	7.7	5	12.5	7	10.6
Mathematical processes	Connections	12	46.2	10	25	22	33.3
	Problem Solving	12	46.2	9	22.5	21	31.8
	Reasoning and Proof	6	23.1	5	12.5	11	16.7
	Communication	2	7.7	6	15	8	12.1
	Representations	2	7.7	-	-	2	3
Attitudes	Interest/ Engagement	5	19.2	10	25	15	22.7
	Awareness about the importance and potential impact of mathematics	3	11.5	8	20	11	16.7
	Self-confidence	3	11.5	2	5	5	7.6

Another category in the teacher responses was related to outcomes on the mathematical process skills ranging from problem solving to communication. Under the outcomes of mathematical processes, we searched for evidence about the ways of acquiring and applying knowledge identified by NCTM (2000). Most of the teachers reported that they observed the most significant improvement in problem solving and communication skills of their students. Both program developer and practitioner teachers also stressed the development of transfer skills that include using mathematical knowledge to solve real-life problems and integrating mathematical knowledge to other disciplines. A program developer teacher explained this situation as follows *"...They used their mathematical knowledge in different fields, like engineering. They realize that science is in a part of everyday life and mathematics is everywhere".* The similar emphasis on connection, problem solving, and communication standards highlighted by both groups of teachers is closely related to the nature of the earlySTEM program they implemented. Unlike the practitioner teachers, the program developer teachers evaluated their students' outcomes through all five process standards that characterize "doing" mathematics. For instance, there was no practitioner teacher focusing on representations while explaining students' mathematical outcomes. However, one of the program developer teachers explained that students began to create and use different representations to communicate mathematical ideas with the following words:

"It was important to try to measure the objects or students saw around them by using a rope and a lego toy. I often started to hear sentences like I walked three cars or I stretched as long as a lego. Even in their free time, using their long or short concepts in various games with their friends helped them to develop their awareness."

In addition to the emphasis on mathematical learning areas and process skills, teachers mostly addressed the development of students' attitudes towards mathematics through the earlySTEM program. The most frequently cited attitudinal outcomes were that the students developed self-confidence about their ability to succeed in mathematics, increased their interest in mathematics, their active engagement in learning, and lastly understood the importance and potential impact of mathematics. In contrast with the outcomes focused on content and process standards, no remarkable discrepancy was observed between program developer and practitioner teachers' reviews on students' attitudinal outcomes. Indeed, based on their observations both the program developer and the practitioner teachers held that the earlySTEM program helped them to break down the stereotype on negative perception towards mathematics and to change students' attitudes from negative to positive to some extent. According to them, such changes encompassed an increase in motivation to learn more and enjoyment in mathematics learning. Exemplary quotes include:

"Students' eyes shined during the process. Their self-confidence in doing mathematics increased. They all acted like a professor." (Practitioner)

"With the earlySTEM program, the students realized that the mathematics was not just a lesson topic and the mathematics knowledge could be applied in the life they live in." (Practitioner)

"Our students have developed a product that is difficult at first, and they reassured their confidence thanks to this. They discovered that mathematics course was enjoyable and how it is intertwined with our daily life." (Program developer)

Interestingly, the practitioner teachers mainly tended to explain students' outcomes through only one dimension and the majority included content-based explanations. They mentioned fewer process standards and often identified these skills without any clarification. A sentence that "*I think that the concepts such as problem solving, logic, geometric shapes, and patterns etc. are given to the children*" shows that their evaluations were limited to just one aspect of outcomes. However, the program developer teachers had a tendency to evaluate students' mathematics outcomes with a broader perspective and focus on skills that imply "doing math" more. Several exemplary quotes from teachers having this evaluation are provided below:

"...I believe that it contributes to the points such as persistence in problem solving, thinking and trying again, finding wrong answers, asking why questions and seeking answers for thoughts."

"It made positive contributions to the search and use of information. They learn and experience the steps of problem solving. They concluded that a problem can have multiple solutions."

> *"Mathematical thinking skills improved. They were able to think geometrically with the given shapes. It has become easier for them to embody abstract topics."*

The program developer teachers also had a tendency to emphasize process standards while expressing students' development on mathematical learning areas and positive attitudes. For instance, one teacher highlighted the students' improvement in associating mathematics with other disciplines as well as content with such words that *"Students have learned what they can do to solve the problems related to mathematics faced in daily life. They have associated subjects in mathematics like patterns, ornament, measurement, measuring time etc. with daily life."* In another instance, a teacher tried to explain students' positive attitudes by emphasizing connections between mathematics and real-life: "*They realized the interdisciplinary aspect of mathematics more clearly. I think it creates awareness among students. In fact, we may say that they realized the idea that life is interdisciplinary."*

Based on the individual teacher responses, most of the teachers (59 out of 66) viewed that the earlySTEM program had a positive impact on their students' mathematics outcomes although they focused on different dimensions: increasing knowledge in specific learning areas, developing mathematical process skills, and cultivating positive attitudes towards mathematics. Teachers who considered the earlySTEM program had no or little effect on students' mathematics outcomes were all practitioner teachers. Some of these teachers, especially preschool and first grade teachers, argued the relatively high level of mathematics-based theme for the grade level of students, while the others identified the lack of PD as a reason. For example, one teacher underlines the necessity of PD about the program for reaching desired mathematical outcomes by stating:

> *"I don't think it makes a big difference. Because a STEM lesson, which should be implemented seriously by expert teachers, should be well-prepared. If it is desired to be successful in this regard, this course should be given by academicians, or the teachers who will give the course should participate in a professional development program. It is not an area to learn with one-day teacher training."*

Science Outcomes

The participants were asked about their students' science outcomes as they implemented the earlySTEM Program. Their responses were categorized as conceptual, behavioral, and attitudinal outcomes as indicated on Table 3. This categorization was inspired by Furio, Vilches, Guisasola & Romo's (2002) study where they investigated teachers' views on goals of science education. Considering the teachers' responses on the science outcomes of the earlySTEM program, the researchers identified and categorized the codes listed on Table 3.

Among the conceptual outcomes, learning scientific concepts and content was mentioned mostly by the participant teachers. The teachers were likely to list the scientific concepts that were included in the earlySTEM themes. Some teachers compared the scientific content covered in the earlySTEM program with the content in the Science Curriculum and appreciated more when there were intersections in between the programs as mentioned by a practitioner teacher:

"I think it [the earlySTEM Program] is more beneficial for some of the learning objectives. It is more useful for the learning objectives related to pulleys and forces. After all, most of the scientific topics could be taught through STEM practices."

Table 3. Categories and Codes on Students' Science Outcomes by Teacher Roles

Category	Codes	Program developer teachers		Practitioner teachers		Total	
		f	%	f	%	f	%
Conceptual	Learning scientific concepts	10	38.4	15	37.5	25	37.9
	Association between scientific concepts or science	-	-	6	15	6	9
	Association of scientific concepts with daily life	4	15.4	3	7.5	7	10.6
	Association of science with other disciplines	1	3.8	2	5	3	4.5
	Learning about STEM careers	1	3.8	4	10	5	7.6
Procedural/ Behavioral	Science process skills	4	15.4	6	15	10	15.2
	Skills outlined in the STEM Cycline	4	15.4	6	15	10	15.2
	Doing/implementing science	1	3.8	9	22.5	10	15.2
Attitudinal	Awareness	4	15.4	3	7.5	7	10.6
	Curiosity	2	7.7	5	12.5	7	10.6
	Interest/positive attitude	5	19.2	10	25	15	22.7

Remarkably, the teachers, who tended to list only the newly acquired scientific concepts as the science outcomes, were all from the practitioner teacher group. In other words, the rest of the study group included multiple science outcomes identified by more than one code on Table 3 in their responses. This was an important finding on the implications of different roles of teachers on their conceptualizations of the earlySTEM program.

As an expected case, the grade level that teachers were working with affected their responses. Such that, a 1st grade teacher, who was a program developer teacher, mentioned the program as an aid to introduce scientific concepts:

> *"Although there are no science classes in the first grade, students get to know green energy resources (hydro energy, geothermal energy, solar energy, and wind energy etc.) and explore daily uses of pulley systems in daily life."*

Interestingly, one practitioner first grade classroom teacher responded that *"There is no science content in the first grade."* These two different teacher responses somehow reflected willingness and unwillingness to include STEM by relating the earlySTEM content to current curriculum.

Some of the pre-school teachers had concerns about age appropriateness of the earlySTEM program and one program development teacher pointed out that their students could not make the scientific investigations fully and teachers had to complete the product development phase themselves. These responses had some reflections on teacher related outcomes and gave feedback for the improvement of the program considering students' needs at different age groups. Among the conceptual science gains, relating science with daily life was frequently cited by both groups of teachers, while the association between scientific concepts was mentioned only by a few practitioner teachers such as recalling a student gain about learning the relationship between a dam and electricity. Association of science with other disciplines was revealed seldom by the teachers as in the case of a program developer teacher:

> *"They become aware of branches of science. They realize which lessons are related to science."*

As the last conceptual science outcome, a limited number of teachers brought up learning about STEM careers, although each earlySTEM theme was associated with multiple STEM careers. Introducing career options could be a new practice for the teachers but the association was clearly introduced in the Teacher Booklets. Regarding the procedural outcomes, the same percentage of teachers from both groups declared development of science related skills (see Table 3). Chiappetta and Koballa (2002) proposed a classification of science process skills as basic skills (observing, measuring, inferring, predicting, and communicating) and integrated skills (controlling variables, hypothesizing, experimentation, and data interpreting). This is a widely accepted classification for skills to be taught and practiced in science classes. A program developer teacher determined one of gained/improved student skills as:

> *"They became better observers after talking about green energy and ecosystems in My Green World Theme. Even, they were more into observing nature…. Considering our pre-school curriculum, they were able to display observation, estimation, and inferring skills."*

In addition to basic science process skills, some teachers included integrated skills that are also outlined in the STEM Cycline (Figure 2) in their responses. For instance, a program developer teacher explained that:

> *"The program encourages kids to make investigations and observations and to evaluate them… Kids put forward their research and observations. … They share their research with friends."*

Experimentation is a frequently pronounced science process skill among the teachers but we realized that they also notified doing and implementing science and even making sense of science as interpreted by a practitioner teacher:

> *"Students took the opportunity to use the knowledge they learnt in the science lesson by doing the projects in the earlySTEM Program. They even tried to match the science concepts with the themes in the program. Some of them adapted the themes to the subjects they learnt."*

This response and a few similar teacher responses also imply that there were limited or no science applications implemented during science lessons before the earlySTEM program. This finding should be discussed both in terms of student and teacher outcomes.

The teachers from both groups included attitudinal aspects in their responses. In terms of awareness, environmental issues came forward as science outcomes as declared in one of the program developer teacher response:

> *"...They [students] shared the environmental news with excitement. They become more sensitive towards the environment. They become aware of green energy resources, environmental scientists, landscape, and design."*

Different from mathematics outcomes, curiosity and willingness of knowing, asking questions were also cited by teachers as attitudinal science outcomes. The teachers associate students' interest towards science by doing science and they appreciated the program since it presents several project ideas as indicated in a practitioner teacher response:

> *"Students ask questions like: When will we do experiments? Can we use the laboratory in the next year as we grow older? They showed their interest with these questions and I explained that we build this relationship at every step of our [earlySTEM] projects. They even made guesses for the coming projects."*

Life Skills

The participants also identified their students' life skills that *"enable individuals to deal effectively with the demands and challenges of everyday life"* (World Health Organization, 1993, p.1) as a result of implementing the earlySTEM Program. Their responses were categorized under three categories: Teamwork, communication, and motor skills as indicated on Table 4.

Among the life skills that teachers observed in their students during the implementation of the earlySTEM program, teamwork was the most frequently stressed by the both groups of teachers. Points related to teamwork mainly concerned on how to work together effectively towards a common purpose. Under this category, the teachers focused specifically on various aspects of group work such as working collaboratively, being aware of teamwork and its responsibilities, and being flexible towards different ideas. As an expected result, the majority of the teachers highlighted that their students learned to work effectively within a group. According to these teachers, this often brings along the sense of responsibility and the idea of a common product/solution.

> *"The earlySTEM program has helped my students improve their group working skills. The activities supported the development of joint decision making and project development skills."*

Table 4. Categories and Codes on Life Skills related Outcomes by Teacher Roles

Category	Codes	Program developer teacher		Practitioner teacher		Total	
		f	%	f	%	f	%
Teamwork	Collaboration	6	23.1	17	42.5	23	34.8
	Awareness of group work	10	38.5	8	20	18	27.3
	Respecting each other's ideas	5	19.2	10	25	15	22.7
Communication	Expressing oneself	4	15.4	8	20	12	18.2
	Socializing	4	15.4	7	17.5	11	16.7
	Presentation skills	1	3.8	9	22.5	10	15.2
Motor skills	Hand skills	2	7.7	9	22.5	11	16.7

Besides teamwork, another prevalent category identified among teachers' responses was communication. The participant teachers focused on the skills especially expressing one's self, making presentations, and relationships with friends under *the communication* category. Notably, communication skills were mentioned by each of the program developer teachers as a life skill. Like the practitioner teachers, they pointed out that the earlySTEM program enables students to learn how to express themselves through group and class discussions. Surprisingly, both groups of teachers underlined that expressing themselves clearly contributes to reinforce students' self-confidence and foster the idea that "*I can do it*". This can be considered as a striking result, because it was also an indication that it enabled teachers to realize what the student could do when the students were given the opportunity:

> *"They also made progress in communicating what they thought, making presentations to a group, and presenting what they were researching. Their self-confidence and beliefs that they can do improved."* (Practitioner)
>
> *"It [earlySTEM program] provided students with skills to express themselves and increased their self-confidence. It has an important success in terms of being able to speak in public and being encouraged."* (Program developer)

In addition to *expressing oneself*, teachers also mentioned improvement in students' socializations under the communication category. They stated that communication and group work among students contributes to strengthen their social aspects so improve relationships with friends. Unlike the program developer teachers, the practitioner teachers emphasized the presentation skills during the talk in public more and evaluated these skills under the life skills by stating "*They [students] learn to make a presentation using the tone of voice and body language while speaking in front of a community.*"

Like in students' science and mathematics outcomes, the program developer teachers evaluated students' life skills with more than one aspect than practitioner teachers and mostly addressing different dimensions of teamwork and communication:

> *"Sharing with each other and responsibility in the group. The most important one was the fact that students become individuals who can express themselves to the community, which increases their self-confidence."*

Under the life skills, another prominent category raised by the teachers was the development in students' motor skills. It was mainly emphasized by the practitioner teachers. It was noteworthy that practitioner teachers at all levels evaluated being able to grip and use objects purposely as important life skills while the program developer teachers did not find them remarkable to mention. In fact, a 4th grade program developer teacher focused on the difficulty of using material, which was perceived as an opportunity to develop students' motor skills by the practitioner teachers, as in the following example:

> *"I know that we have difficulties in the use of tools and equipment used in the construction of dam and Amsterdam houses. Despite being in the 4th grade, it was difficult to use cutting tools and control them."*

Remarkably, the teachers' responses indicated that communication and teamwork skills were intertwined and constantly feeding each other during the implementation of the earlySTEM program. One teacher explained the intertwinement by stating "*Firstly students learned to work with the group. This elicited the socializing phase. Communication of students with each other has gradually improved*". Aligned with this idea, another teacher pointed out that intertwinement between teamwork and communication and its benefits were still valid for students who had problems among them:

> *"I observed that communication with their friends becomes stronger for my students who are in conflict by being in the same group and collaboration."*

Regardless of their roles, several teachers teaching at early grades mentioned their concerns about team work depending on students' age and the role of teamwork in eliminating these concerns within the earlySTEM program. In the following example, a teacher emphasized the collaboration among young students and its implicit effect on learning:

> *"I think that acting together is effective in creating solutions and solving problems. Despite their young age, we have worked well on collaboration and subject learning."* (Program developer)

Another teacher also mentioned that the nature and structure of the earlySTEM program promotes teamwork and students become more likely to understand the necessity of teamwork in reaching solution, and a result to develop group awareness:

> *"Preschool age groups may have some difficulty in carrying out collaboration or group activities. But I*

think that it contributes to concepts such as group awareness and friendship as students observe that they cannot reach a conclusion without teamwork in the STEM course." (Practitioner)

It was remarkable that both groups of teachers highlighted the teamwork even though they had some negative group work experience with young students. Indeed, this provided important implications for the earlySTEM program.

Research Question 2: How do program developer teachers and practitioner teachers conceptualize teacher outcomes in the earlySTEM program?

In the open-ended questionnaire, we asked the participant teachers' feedback about what they thought about their involvement in the program development and/or implementation of the earlySTEM program. The answers of teachers are summarized in four major categories as (1) pedagogical content knowledge, (2) subject matter knowledge, (3) change in classroom teaching practice and (4) professional development opportunities. Table 5 presents categories and codes emerged from the data.

Table 5. Categories and Codes on Teacher Outcomes

Category	Codes	Program developer teachers		Practitioner teachers		Total	
		f	%	f	%	f	%
Pedagogical Content Knowledge	Knowledge of Curriculum	23	88.5	--	--	23	34.8
	Knowledge of content and teaching	6	23.1	2	5	8	12.1
Subject Matter Knowledge	Science	2	7.7	4	1	6	9.1
	Mathematics	1	3.8	4	1	5	7.6
	Technology	--	--	5	12.5	6	9.1
Classroom teaching practice	Instructional methods employed	8	30.8	10	25	18	27.3
	The ways technology used in instruction	3	11.5	1	2.5	4	6.1
Professional development opportunities	Establishment of Professional Learning Community	1	3.8	4	1	5	7.6
	Ongoing professional development	12	46.2	15	37.5	27	40.9

Responses with fewer frequencies were not displayed in the table.

Table 5 indicates that teachers' conceptualized development resulting from their participation to the program development and/or implementation program under four major areas. These areas point out teachers' development in terms of knowledge and classroom practice. Teachers also reported their willingness for further professional development opportunities in STEM areas.

Pedagogical Content Knowledge

Under the category of pedagogical content knowledge we used Ball et al., (2008) framework, and therefore, looked for evidence within three codes: (1) Knowledge of curriculum, (2) Knowledge of content and teaching, and (3) knowledge of content and students (because of the few responses, the code was not indicated in Table 5). Most of the teachers stated that their knowledge of a STEM curriculum was enhanced after the participation of the program. It is not a surprise that all teachers who reported development in this area were program developers. Their involvement in program development activities empowered them mostly in terms of anticipating the implementation process. Because they were aware of major dimensions of the STEM curriculum and contributed to the development of the program, they showed ownership of the process by anticipating students' reactions, students' possible questions, and possible strengths they might experience. For example, one teacher asserted that *"My participation in this program enabled me to take preliminary precautions for any problems that may occur during the implementation. In addition, I had the opportunity to do research during the preparations I had to do (STEM education) as a teacher which would support me in the age group (that I teach) to make the practice more effective and to provide permanent learning. I was able to find the opportunity to prepare the environment in which the implementation would be made."* Teachers showed significant effort to implement the curriculum in an effective way and knowing the major dimensions and implementation aspects gave them confidence throughout the program. *"We knew how to follow and improve the steps to be implemented"*, and *"Experiencing the program while developing the program made it easier to implement and internalize it."* are the statements underlining this aspect.

Under the knowledge of content and teaching we searched for evidence about STEM teaching principles. Most of the teachers, who reported a development in their knowledge of content and teaching, were among program developer teachers. Only two practitioner teachers reported development in this area and focused on real-life integration aspects. The program developer teachers underlined the real-life integration; however, interdisciplinary nature of STEM disciplines also came forth. For example the statement, *"I also noticed that professions such as architecture and engineering are essentially handled together with arts and science."* gave clues about interconnectedness of the disciplines. Another teacher showed their acknowledgement of STEM as a process and STEM Cycline by indicating *"Based on an existing problem, I learned to derive original and different ideas and to create a different product in line with these ideas. I learned to plan and aim to progress with much more curiosity in the next stages."*

Under the knowledge of content and students, we focused on evidence about teachers' statements related with students' learning when pursuing the earlySTEM activities. Two teachers, one program developer, acknowledged how the earlySTEM program facilitated students learning, the other practitioner teacher, for example, indicated that *"I think I supported my students throughout the themes in terms of a more detailed and hands-on learning process. They experienced the angle concept they saw in mathematics lessons and I could observe their lack of knowledge by this."*

Subject Matter Knowledge

The participant teachers also discussed their gains in subject matter knowledge. Because all teachers in the current study were preschool and classroom teachers, it was valuable to observe that by teaching the earlySTEM program, teachers had also deepened their subject matter knowledge in mathematics, science, and technology. Two of the program developer teachers acknowledged that by implementing the earlySTEM program, they had a chance to review their science and mathematics subject matter knowledge. Besides mathematics and science, the practitioner teachers mentioned further development of subject matter knowledge in the area of technology. One teacher asserted that their computer literacy had increased, whereas another teacher acknowledged that through the implementation of the "Scratch" program, they learned about programming. In a way, the teachers implied that they could find opportunities to implement relatively novel teaching approaches in the classroom through the earlySTEM program.

Classroom Teaching Practice

Under the change in classroom teaching practice, we looked for evidence of change in instructional methods employed and change in the ways technology used in instruction. Most of the teachers reported that they changed their teaching practices in terms of the instructional methods they use. Program developer teachers put forward hands-on learning, student-centered teaching methods, experiments, observations, and group-work as the teaching-learning methods and strategies they started using as they implemented the earlySTEM program. They also wrote about the gains they observed in students' achievement, interest, and motivation. *"We have started to do more activities on these topics, which learning by doing is effective and permanent."* and, *"Emphasis was placed on working with more innovative methods, experiments and observations, and group work of students. I started to think in many dimensions."* are among the assertions of program developer teachers. Ten practitioner teachers underlined the fact that they used more instructional methods, which are facilitative and support students' learning. However in their statements, the methods are mostly described in a vague way such as *"earlySTEM education is a system applied in the best education models in the world and together with our students we developed ourselves in terms of different teaching methods."* The teachers mostly emphasized hands-on learning and *"helping students understand abstract concepts in a more concrete way"*. It was not a surprise that both groups of teachers changed their instructional methods in a similar way due to the nature of the earlySTEM program they implemented. However, it was worth underlining that program developer teachers could name different instructional strategies and relate them with students' learning. Another aspect of change in classroom practice underlined by teachers was the ways technology used in the classroom. Most of the teachers who reported this aspect were program developer teachers. Few teachers but in the program developer group, implied that they also changed their approaches to deal with student diversity and classroom management. The statements of the teachers written about this aspect, however, were mostly vague; the teachers only appreciated students' different learning habits and the potential of the earlySTEM program regarding differentiation.

Professional Development Opportunities

The teachers were aware that participation in program development and implementing the earlySTEM program created opportunities for their professional development. Two codes, namely, establishment of professional learning community and ongoing professional development had emerged. For the establishment of a professional learning community, both program developer and practitioner teachers acknowledged that they taught and learned from each other. This implies that a reciprocal relationship had occurred between the program developer and practitioner teachers. For example, one program developer teacher stated that *"we helped other teachers in their classroom implementations",* whereas a practitioner teacher asserted *"I frequently received help from our teacher about her field and teaching, and I also enjoyed getting information that would contribute to my profession."*

For ongoing professional development opportunities, the program developer teachers reported that they gained a different perspective and positive attitude towards mathematics and science disciplines. The teachers related this attitude change to their implementations and to experience the excitement and motivation with their students: *"As a teacher, I was also interested in learning different topics. I drew the same excitement with my students and I accompanied them. It was a lot of fun to do different projects and use different materials at the same time."*

The program developer teachers also acknowledged that implementation of the earlySTEM program encouraged them to do more research for their professional development. The teachers did more research to motivate their students, to implement the activities accurately, and to improve their knowledge about the content: *"Doing different studies made me very happy. Thinking creatively and constantly improved myself and doing research helped me to change my thoughts and to be informed about new topics".* The program developer teachers also demonstrated willingness to transfer their new knowledge and skills to other disciplines. For example, one teacher asserted that *"I noticed that there are aspects that I have transferred to other lessons, since scientific thinking has project steps, I think that it can be adapted to other lessons as much as possible so that students can internalize this idea (STEM concepts) already, at least I try to create opportunities."* One program developer teacher was so explicit about their professional development by stating, *"I think I found myself in this activity (the earlySTEM program) and I realized myself".*

The practitioner teachers also reported positive attitudes and change of perspective towards mathematics and science disciplines. However, their arguments were mostly superficial, as they explained the change in their attitudes and perspectives: *"My perspective on mathematics and science has changed as a lesson. It [the earlySTEM program] allowed me not to perceive them as just a lesson."* Doing more research was another common aspect that both groups of teachers discussed. However, the program developer teachers elaborated more on this aspect because they felt the need to prepare themselves more strongly for the activities. *"I became* *a teacher supporting my students' skills such as research and inquiry. I accompanied them during the themes, while doing Amsterdam houses; I observed and watched the products with the children. With them, I actively participated in the activities and became an educator who researched and questioned."* Uniquely, two practitioner teachers also underlined that they became more curious about the content of the program. The practitioner teachers also showed more willingness to transfer their new knowledge and skills to other disciplines they teach. Most of the teachers stated that they started to use "coding activities" in other lessons. And as a teaching method, teachers also explained that they started to use "learning by doing methods" in their other classes.

Discussion and Conclusion

The purpose of the current study was to examine the perceived outcomes of students and teachers resulting from teachers' different roles in the earlySTEM program. We investigated the results with respect to two groups of teachers:

1- Teachers who implemented the earlySTEM program (practitioner teachers),
2- Teachers who contributed to the program development process of the earlySTEM program and implemented the program (program developers).

The overall findings of the study pointed out outcomes for students in terms of science and mathematics knowledge and skills, as well as their life skills. Teachers also reported critical outcomes in terms of pedagogical content knowledge, subject matter knowledge and change in classroom teaching practice.

Looking at the results comprehensively, it is apparent that both the program developer and practitioner teachers viewed the earlySTEM program as an ideal venue for the application of mathematics knowledge and skills. Both groups of teachers emphasized that the program promoted students to make connections with real-life by providing math-application opportunities. However, the program developer teachers evaluated students' mathematics outcomes with more emphasis on process standards than the practitioner teachers. They were aware that its benefit was more than just learning content knowledge as emphasized by NCTM (2000), and in fact that was related to the "*habits of mind developed as they unearth the meaning behind the mathematics*" (Hefty, 2015, p. 425). Therefore, the obtained data indicated that the impact of the PD is noteworthy for teachers on evaluating students' outcomes with a broader perspective.

Particularly, increase in students' self-confidence about their ability to succeed in mathematics and their motivation was a salient attitudinal outcome stated by the teachers. The teacher responses revealed that students engage in authentic tasks based on real-life and exhibit perseverance as they develop self-confidence and motivation. This is in line with the recommendations of National Academies Press (2014), which stated that teaching STEM subjects in a more integrated way, especially in the context of real-world issues, is a major contributor to make these fields more relevant to students and as a conclusion to increase their motivation and achievement. Furthermore, the study findings support the claims of Wong and Wong (2010) who stated that authentic STEM activities provide not only better understanding of concepts but also increase in interest and motivation towards these subjects (Kutch, 2011; Lee, 2013).

Science was the most pronounced discipline among the other STEM disciplines by practitioners and students (English, 2006; Moore et al., 2014). In this study, the teachers identified more student gains in terms of science rather than mathematics. The teachers perceived the earlySTEM program mostly as a supplement for other school courses and acknowledged more as there were more intersections between the learning objectives of the national curricula and the earlySTEM program. However, they were also aware that the program aims to teach beyond the basic science process skills and the science content covered at K-4 level. Similar to the mathematics gains, the program developer teachers had a wider perspective and were able to identify more than one science outcome and mostly from different categories as a consequence of their participation in the program development process.

The study presented important insights to science education practices. The teacher responses revealed that limited hands-on science activities, investigations, and experiments were implemented in the elementary classrooms before the earlySTEM program as also discussed in the literature (Duschl, 2008; Tan & Wong, 2011). The program somehow supported the inclusion of more hands-on, student-centered, and inquiry-based science practices.

In this study, environmental awareness was a prominent attitudinal outcome identified by the teachers. The interdisciplinary nature of sustainability and STEM education have several intersecting points such as technological designs for solving problems, impact on social sciences, problem solving skills (Bybee, 2013). Environmental problems can be introduced as a well-structured context for STEM classes. For instance, in the earlySTEM program, “My Green World” theme was designed to present environmental issues in a problem-based approach.

As an expected result, both groups of teachers could list more students’ gains in terms of life skills rather than mathematics and science. Mostly, they pointed out that the earlySTEM program develops communication, teamwork and cooperation skills of elementary-school–aged students. It is compatible with the research literature that the well-designed STEM activities may create active, creative, and communicative human beings (Bahri, Suryawati, & Osman, 2014; Tolliver, 2016). Therefore, it is important to consider such programs or activities reflecting collaboration, encouraging students’ commitment and ownership, like the earlySTEM program, as potential for students to learn from each other and develop their life skills at K-4 level.

Considering the nature of interdisciplinary nature of STEM education, the teacher survey should have included some direct questions about engineering and technology disciplines just like mathematics and science. The researchers intentionally focused on mathematics and science related outcomes and the teacher survey included two more questions about some student and teacher outcomes. The teacher responses from both groups did not include any student skills related to technology and engineering although ‘my computational world’ and ‘my world of machines’ themes were centered on these two STEM disciplines, respectively. Engineering was present in some teacher responses as a context to teach mathematics or to introduce various STEM disciplines. Exceptionally, technology was present in teacher responses related to teacher outcomes; both groups of teachers mentioned that they learnt about technology and basics of coding while preparing for and implementing the earlySTEM program. It could be concluded that these teachers needed some time to transfer these new knowledge and skills and conceptualize the student outcomes about technology.

Teachers' conceptualizations about their outcomes resulting from their participation in program development and implementation of the earlySTEM program revealed that they developed themselves in terms of pedagogical content knowledge and subject-matter knowledge. Furthermore, teachers also reported change in their classroom teaching practices and acknowledged that they found opportunities for continuous professional development. It is also evident in the research literature that high-qualified, research-based PD may facilitate change in teachers' classroom practices resulting in improved student learning outcomes (Cohen & Hill, 2000; Czerniak et al., 2005; Saunders et al., 2009).

From the point that effective STEM teacher preparation strengthens teachers' outcomes, especially pedagogical content knowledge and subject-matter knowledge were reported as crucial outcomes expected from a STEM PD (Cuadro & Moreno, 2005; Hewson, 2007; Jesky-Smith, 2002, Nadelson et al., 2012; Nadelson & Nadelson, 2010; Plourde, 2002). Interestingly, only the program developer teachers reported development in their pedagogical content knowledge in the current study. This result underlines the importance of involving teachers in both program development and implementation processes. Related studies implied that practices of teachers with strong content and pedagogical knowledge had more impact on students' learning (Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Goldhaber, 2002; Rice, 2003; Wayne & Youngs, 2003). In this context, teachers will be more likely to integrate real-life with STEM disciplines in a rigorous way when PDs provide support for development of their pedagogical content and subject-matter knowledge.

Along with a deep understanding of the subject-matter, an effective PD has also outcomes related to teaching practices (Avery & Reeve, 2013; Han, Yalvac, Capraro, & Capraro, 2014). Similar to the findings of the current study, STEM PD activities' impact on teachers' classroom practice was well reported (Avery & Reeve, 2013; Guzey et al., 2014; Roehrig, Moore, Wang& Park, 2012). The reason for only program developer teachers reporting change in their pedagogical content knowledge may be related to their involvement in the earlySTEM program development process. PDs that actively engage teachers found to be more effective in terms of teacher change than expert-centered PD (Desimone, 2009; McLeskey, 2011). With regards to changes in practice in the current study, the program developer teachers gave more detailed answers about the methodologies they started to use, whereas the practitioner teachers' were not specific in terms of the change in their teaching practices.

Besides development in pedagogical content knowledge, subject matter knowledge, and change in practice, increased teacher confidence was another outcome that lead to effective implementation that facilitated students' learning (Baxter, Ruzicka, Baghetto, &Livelybrooks, 2014; Nadelson & Seifert, 2013; Nadelson et al., 2012). Evidence for teacher confidence in the current research reported under the opportunities for ongoing professional development, where teachers underlined their enthusiasm to do more research and to transfer the new methodologies to other disciplines. Under the category of opportunities for professional development both the program developer and the practitioner teachers acknowledged the support and supervision they gave and received during the entire academic year. In other words, they were content with the emerged professional learning environment. For an effective implementation, evidently, teachers valued collaborative practices where they supported each other both within and across subject areas (Hollins, McIntyre, DeBose, Hollins, & Towner, 2004; Lesseig, Slavit, Nelson, & Seidel, 2016).

To sum up, this study investigated different roles of teachers in the earlySTEM program and how they conceptualized student and teacher outcomes in the program. There was a clear pattern that the program developer teachers generally presented more links to various student skills and conceptual gains, and professional outcomes for themselves. Although there was also insightful feedback from the practitioner teachers, they strongly indicated their willingness to attend the program development teacher group.

Regarding teachers' critical role for implementing any novel learning approach, the current study and related studies point out the need for more research studies on STEM teacher learning that involve teachers in the program development process and allow strong collaboration between teachers and expert-teachers (Han et al., 2014). Further research with different methodologies and research-based classroom implementations will enhance both teachers' and students' STEM learning.

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