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Editorial

Dear IEEJE Readers,

International Electronic Journal of Elementary Education (IEJEE) presents its Vol 13 No 2.

As we all noticed, Covid-19 caused huge threats for our health and the children's educational situations.

Students in elementary education in the entire world have experienced and still are experiencing unpredicted challenges in their schooling and education. So do also their teachers and parents. Educational authorities and teachers are trying to do their bests within their capacities, technological infrastructure and economic realities.

Elementary education in the schools is characterized as an organized teaching-learning activity setting. Schools are in other words are places for 'community of learners'. Cooperation, collaboration and communication with peers in and outside classrooms activities use to create collective learning environments. Covid-19 is threatening the natural conditions for socialization and learning.

Our experiences since March, 2020 have shown that neither educational communities nor educational researchers have been surrenders. As mentioned, this issue of IEJEE was created under extraordinary conditions.

I would like to thank to all contributing researchers, peer reviewers and technical staff who did their best for materializing this issue of IEJEE.

Sincerely,

Dr. Hayriye Gül Kuruyer, Ordu University

Acting Editor-in-Chief

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Expectancy Value Theory as a Tool to Explore Teacher Beliefs and Motivations in Elementary Mathematics Instruction

Corinne Thatcher Day*

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*Correspondance Details: Corinne Thatcher Day, Montana State University Billings, College of Education, Department of Educational Theory and Practice, MT, USA.
E-mail: corinne.day@msubillings.edu
ORCID: http://orcid.org/0000-0003-0391-7036

Abstract

This case study explores the utility of Expectancy Value Theory (EVT) as a framework for studying elementary teachers' beliefs and motivations with respect to reformed mathematics instruction. A model for coding and evaluating qualitative data using EVT is proposed and illustrated using interviews with three primary school teachers in an urban school district in the United States. Results from the study indicate that anticipated costs associated with reform instruction, including not covering required content and not meeting district benchmarks, function as strong inhibitors to reform, even among teachers who value reform instruction, who exhibit a strong sense of self-efficacy, and who believe in their students' capacities to succeed with reform-oriented instruction.

Keywords:

Elementary School Teachers, Expectancy Value Theory, Mathematics Instruction, Teacher Attitudes, Teacher Motivation

Introduction

In the 1980s the mathematics education community in the United States, spearheaded by the National Council of Teachers of Mathematics (NCTM), initiated a new era of reform efforts motivated by the constructivist belief that children learn mathematics best through active and collaborative engagement in problem solving tasks (NCTM, 1980; 1989). Citing best practices in math instruction from around the world, NCTM has promoted a more student-centered approach to mathematics teaching and learning than has traditionally characterized U.S. classrooms (2000; 2014). Despite over three decades of calls for change, however, most math instruction in the United States remains mired in long-eschewed behaviorist approaches to education in which teachers present step-by-step instruction before turning students over to plug and chug through sets of prescribed practice problems (NCTM, 2014). Even teachers with extensive training in reform-based practices often struggle to faithfully implement reform instruction (Louie, 2017a; 2017b).

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Numerous reasons for this struggle are evident in the mathematics education literature, including disciplinary and professional constraints on educators (Smith, 2012; Stemhagen, 2011; Warfield et al., 2005; Webel & Platt, 2015; Windschitl, 2002; Yurekli et al., 2020) as well as educators' efficacy beliefs about self and students (Abrami et al., 2004; Cross Francis, 2015; Rousseau, 2004; Thompson, 1984; Warfield et al., 2005; Yurekli et al., 2020). A complex interplay between internal beliefs and external constraints influences teachers' instructional decisions. Beliefs also vary depending on contexts, "so to examine beliefs without paying close attention to the unfolding of teachers' practices through interaction within contexts would be methodologically and analytically inappropriate" (Cross Francis et al., 2015, p. 338). The interaction between beliefs and contexts requires a theoretical model that extends beyond teacher beliefs and enables researchers to capture other factors influencing educators' instructional choices.

Expectancy Value Theory, originally proposed by Wigfield and Eccles (2000) to study academic achievement among students and adapted for use among teachers by Abrami et al. (2004), is a promising model for studying the influences on teachers' instructional decision making because it encompasses both beliefs and the anticipated costs associated with making particular decisions within particular contexts. Using Expectancy Value Theory (EVT) as a theoretical framework for understanding teachers' instructional practices, the present study sought to explore the interactions between teachers' beliefs and their professional contexts to better understand their instructional decisions with respect to mathematics education reform.

Contrasting Instructional Models

The beliefs that mathematics educators hold and the instructional decisions that they make can be characterized along a continuum from traditional to reform instruction, with many teachers' beliefs and decisions reflecting a blend of these two instructional models (Raymond, 1997). Traditional instruction is characterized by teacher who provide explicit, step-by-step instruction on how to solve specific mathematical problems. As Goldsmith and Shifter (1997) describe, "Traditional mathematics instruction is grounded in the belief that students learn by receiving clear, comprehensible, and correct information about mathematical procedures [...] Classroom instruction is organized around the transfer of information from knowledgeable teacher to uninformed student" (pp. 22-23).

On the other end of the continuum, reform instruction is characterized by students actively engaging in problem-solving activities facilitated and designed by teachers who take into account students' prior knowledge, current interests, and cognitive development during lesson planning and implementation. This definition was derived from NCTM's description of high-quality math instruction, in which "mathematics lessons should be centered on engaging students in solving and discussing tasks that promote reasoning and problem solving" and in which teachers should "plan lessons to prompt student interactions and discourse, with the goal of helping students to make sense of mathematical concepts and procedures" (2014, p. 10). NCTM also advocates for teachers to "elicit and use evidence of student thinking" such that they can "assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning" (2014, p. 10).

Promoting reform instruction that enables each and every student to succeed in mathematics is a primary goal of NCTM, whose principals are advocated in the school district that is the subject of this study. Yet upon entering any given K-5 classroom in the study district, an observer is unlikely to witness instruction that falls solidly on the reform end of the instructional continuum and will instead encounter many classrooms in which traditional instruction dominates. As a teacher educator whose pre-service teachers student teach in the district, the researcher wanted to explore the reasons why in-service educators in the district are not implementing reform recommendations to a greater degree.

Study Purpose and Research Questions

The present study contributes to the research literature on teachers' beliefs by exploring the interactions between teachers' beliefs and their professional contexts in relation to their instructional decision-making. Whereas many studies have analyzed mathematics teachers' beliefs, only a few have attempted specifically to incorporate beliefs and institutional contexts within the same model (e.g, Yurekli et al., 2020). This study adds to the existing literature by analyzing the interplay between teachers' personal beliefs and the institutional realities that motivate their instructional choices. In so doing, it responds to Watt and Richardson's (2015) call to "marry" beliefs research with research on motivation in a way that "systematically fosters theoretical cross-fertilization and hybridization" (p. 203).

Specifically, the following research questions were addressed:

- When asked to explain why they feel that their math instruction falls short of reform recommendations, what reasons do K-5 teachers provide?

- Do teachers' expressed reasons for falling short of reform align with the three domains of Expectancy Value Theory?

    - Which of the three domains appears to weigh most heavily in the teachers' instructional decision-making?

    - How might these domains be delineated within a conceptual model to best reflect the efficacy beliefs, values, and costs associated with reform instruction?

Going into the study, it was hypothesized that the participating teachers would believe their job to be to "teach to the test." While this might be viewed as a lamentable outcome of the high-stakes testing environment in which teachers find themselves in the United States, it was nevertheless anticipated that the teachers would subscribe to the importance of procedural fluency and test preparation. Such beliefs permeate the literature and also emerged as a concern among teachers in the study district who had completed an informal survey on reform instruction the year before the present study commenced. Testing was clearly on teachers' minds, but in order to understand in what ways it might impact their instruction, further exploration was needed.

Conceptual Framework

Expectancy Value Theory (EVT) was chosen as the conceptual framework for this study because of its capacity to capture multiple decision-making factors within a single framework. According to EVT, an individual's decision-making process involves a cost-benefit analysis weighing three primary considerations: the expectancy of succeeding in a particular task, the personal value attributed to the task, and anticipated costs associated with pursuing the task (Abrami et al., 2004; Wigfield & Eccles, 2000).
In their quantitative study of cooperative learning (CL) in Canada, Abrami et al. (2004) found that the three domains of EVT (expectancy of success, personal values, and associated costs) aligned well with survey items chosen by teachers to explain their use or non-use of CL. Their findings suggest that EVT can serve as a powerful explanatory model for illuminating the complex relationship between teacher's beliefs and practices. In their study, seven of the ten significant predictors of CL implementation reflected the expectancy of success component of the framework, with the most common factors relating to expectations of students' capabilities. Only one cost item proved to be significant—preparation time to plan for CL—and two value items were significant, including alignment between CL and a teacher's educational philosophy.
While the Abrami et al. (2004) study did not focus on math instruction specifically, it echoes findings from math education research, where similar relationships have been identified between teachers' beliefs about students and their use of reform instructional practices (Rousseau, 2004; Thompson, 1984; Warfield et al., 2005; Yurekli et al., 2020). Further research utilizing the EVT framework is warranted both to confirm its utility in evaluating the impact of teachers' beliefs and motivations on their instructional choices as well as to explore whether expectancy of success remains the most salient decision-making factor in other educational contexts.

Methods

Context and Participants

The study took place in an urban public school district in the northwestern United States. Reform instruction is emphasized by the district's K-5 math coach, a member of the board of directors for the NCTM affiliate in the state. Three K-5 teachers were recruited for the study from a sample of teachers who had completed a voluntary electronic survey emailed to primary school teachers in the district. Forty-five teachers completed the survey, representing approximately one in eight K-5 teachers in the district. The survey asked teachers to identify the frequency with which they utilized ten reform-oriented mathematics instructional practices and to list factors that supported and inhibited their efforts to use these practices. The participants were chosen because their responses reflected the overall sentiments of the teachers who completed the survey. Each participant, like many of the other respondents, indicated on their survey that they utilized several of the ten reform practices but that they were not able to use them to the extent that they would like to due to three main inhibiting factors: the need to cover a large amount of content; the need to ensure students learn standard mathematical procedures; and the need to prepare students for standardized tests.

Each participant taught at a different grade level and worked at a different school in the district. A kindergarten teacher, a second-grade teacher, and a fifth-grade teacher were selected for the study because of the testing requirements within the district. Beginning in second grade, students take state-mandated standardized tests in both the fall and spring. A kindergarten teacher is working with students who are several years removed from the state-mandated testing requirements (although they do engage in district benchmark testing); a second-grade teacher is instructing students during the first year in which they engage in state testing; and a fifth-grade teacher is working with students who are well accustomed to the annual state tests.

Mrs. P, the kindergarten teacher, had 37 years of teaching experience at the time of the study. For most of her career, she had taught in self-contained special education classrooms but had been teaching in regular education classrooms for the past eight years. Ms. S, the second- grade teacher, had been teaching pre-school and early primary grades for 22 years at the time of the study. Mr. C, the fifth-grade teacher, was in his fifth year of teaching in the same grade level in the same school.

Data Collection and Analysis Procedures

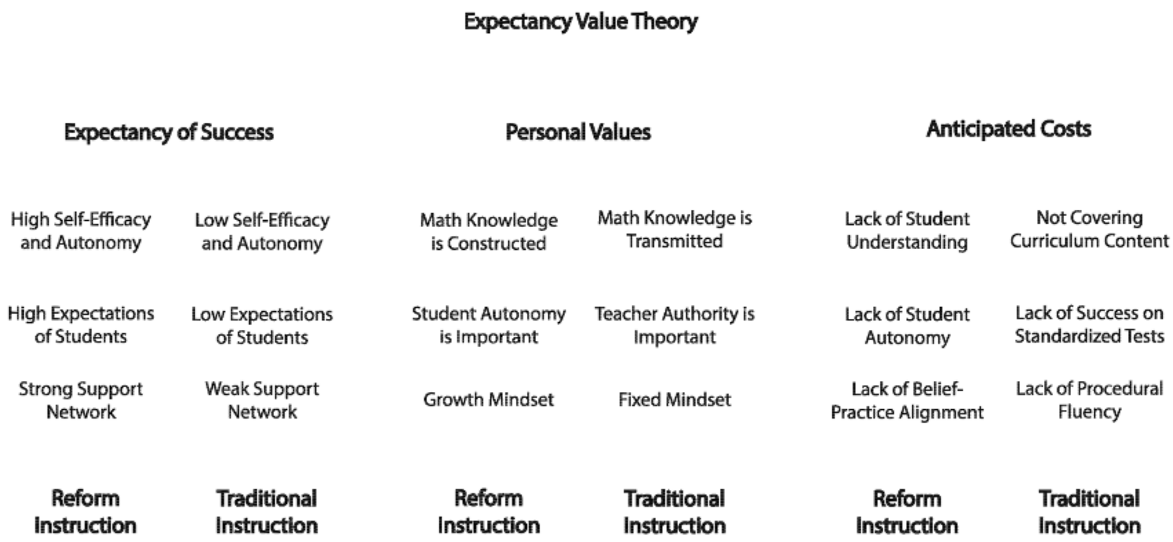
Audio-recorded, one-on-one, semi-structured interview were conducted with each of the three teachers. The recordings were transcribed and imported into NVivo 12 for coding using an a priori coding scheme designed to organize the teachers' responses according to the three domains of Expectancy Value Theory. The section below describes the development of the preliminary conceptual model utilized during the coding process. The researcher remained open to reorganizing the model and to creating new nodes if themes emerged from the data that did not align with the existing domains and constructs. Each transcript was coded and then revisited several weeks later to refine the analysis, at which point several of the constructs within the preliminary model were renamed and reorganized. A codebook is included in the Appendix for reference.

For triangulation, a word frequency query was conducted to explore whether particular words or phrases permeated the interview data. The findings from the coding analysis were further compared against the survey responses that had been submitted by each teacher during the prior school year as well as against researcher memos recorded before and after each interview. Member checks were conducted to ensure that the teachers' responses were accurately interpreted. Each teacher was provided with a draft of this article and given time to provide feedback before the draft was finalized.

Preliminary Conceptual Model

In order to utilize EVT as a framework for this study, each of the three domains (expectancy of success, personal values, and anticipated costs) were operationalized in terms of the literature on mathematics teachers' beliefs and practices. Figure 1 presents a visual model of the relationship between teachers' beliefs and practices through the lens of EVT. Teachers' beliefs, values, and motivations were situated within the model in such a way as to indicate their relationship to instructional practice—reform or traditional—as

Figure 1
Preliminary Conceptual Model



identified in the literature. Each of the model's three domains are described in more detail in the sections that follow.

Expectancy of Success

Teachers' beliefs about students and about themselves are reflected within the expectancy of success component of the EVT framework. Some teachers hold low expectations of their students, believing that their students are incapable of engaging successfully in reform-oriented instruction (Cross Francis, 2015; Gill & Hoffman, 2009; Rousseau, 2004; Thompson, 1984; Warfield et al., 2005; Wilkins, 2008; Yurekli et al., 2020). Other teachers do not feel capable of enacting successful reform instruction or do not feel that they have the authority to diverge from the discipline's long history of direct instruction (Cooney & Shealy, 1997; Cross Francis, 2015; Warfield et al., 2005; Webel & Platt, 2015). Teachers who do successfully enact reform instruction hold higher expectations of their students and of themselves and often enjoy significant institutional and/or peer support (Hart, 2002; Lloyd, 2002; Louie, 2017a, b; Ren & Smith, 2018; Smith, 2012; Thompson, 1984; Wilson & Cooney, 2002).

Personal Values

Personal values are also associated with teachers' use or non-use of reform instruction. Teachers who harbor relativistic mindsets, valuing personal growth and development, are often found to be more successful at implementing reform instruction than teachers who harbor dualistic mindsets, favoring constancy and stability (Cooney & Shealy, 1997; Smith, 2012). In contemporary jargon, a relativistic mindset is akin to a "growth" mindset and a dualistic mindset akin to a "fixed" mindset (Boaler, 2016). Teachers with dualistic or fixed mindsets tend also to view the discipline of mathematics itself as fixed: as a set of procedures and operations to be transmitted and memorized as opposed to a tool for productive thought and inquiry. Consequently, they interpret their role as one of control over classroom knowledge. In contrast, teachers with relativistic mindsets often assume a role of supporting student autonomy and sense making (Boaler & Staples, 2008; Raymond, 1997; Stipek et al., 2001).

Anticipated Costs

Other reasons cited in the literature for not implementing reform-oriented practices include disciplinary and professional constraints such as the need to keep up with district pacing guides, the need to prepare students for standardized testing, and the need to ensure fluency with standard mathematical algorithms (Raymond, 1997; Smith, 2012; Stemhagen, 2011; Warfield et al., 2005; Webel & Platt, 2015; Windschitl, 2002; Yurekli et al., 2020). These constraints reflect perceived costs that might be incurred in exchanging direct instruction for reform-oriented practices. On the other hand, teachers who are unwilling to sacrifice students' understanding of mathematics or to belie their own personal beliefs about the power of reform instruction—regardless of whether curriculum mandates are met, standard procedures are mastered, or standardized test scores are high—are more likely to implement reform recommendations (Abrami et al., 2004; Smith, 2012; Boaler & Staples, 2008). While the constructs within the anticipated costs domain do not represent clear binaries as they do in the other two domains, the set of constructs associated with reform instruction serves as a collective binary when juxtaposed against those associated with traditional instruction: on the one side, priorities associated with students are the focus, while on the other side, priorities passed down by administrators and other higher-level authorities are the focus.

Student Autonomy: Tentative Placement Within the Preliminary Model

Student autonomy appears twice in the preliminary model because the way this construct is discussed in the literature does not clearly indicate to which domain it best belongs. Student autonomy appears relevant to both personal values and anticipated costs. For example, in Smith (2012), "Mrs. Zatechka believed her main job as a classroom teacher was to teach students to think" (p. 319). Mrs. Zatechka did not allow the district curriculum to govern her instruction, and this was both because she valued student autonomy and because she was unwilling to pay the cost of giving up this autonomy in favor of following the curriculum in lock step. Ultimately, an optimal structure for a model of math teacher's beliefs and motivations based on EVT was determined via the research process, as described in the results section.

Results

Overview

For the teachers in this study, a desire to "teach to the test" was not in fact a factor in their instructional decision-making. Nor did a lack of will, desire, or self-efficacy appear to be inhibitors to reform instruction, in contrast to the findings of Abrami et al. (2004). Instead, the teachers all expressed strong reform-oriented beliefs but felt constrained by district mandates, such as trimester reporting goals tied to state and national standards. All of the teachers, especially the early primary teachers, shared a desire for their students to truly understand the mathematics they were learning, and they each expressed confidence in their students' abilities to do so under the right instructional conditions. None of the teachers expressed any statements reflecting personal values associated with traditional math instruction in the conceptual framework. To the contrary, they made many statements aligned with the tenets of reform instruction. In the sections that follow, the research outcomes are organized according to the three domains of the EVT model.

Anticipated Costs

Not Covering Curriculum Content

All three teachers in the study shared an overt concern for a lack of sufficient time to teach mathematics in a more reformed manner. Tellingly, "time" also emerged as the third most frequent word in the word query. The other 20 most frequent words were those that might appear in any conversation about math education such as math, think, and kids. All of the statements made with respect to time were related to the anticipated cost of not covering curriculum content prescribed by the district. Several different reasons were provided by the teachers for struggling to find time for reform instruction while still keeping pace with the curriculum. To accommodate these reasons, three sub nodes were created within the node not covering curriculum content in order to reflect the variety of responses: too much content, time limited by daily schedule, and time lost to testing.

Too much content was the most salient category in the entire data set. Most of the statements made by Mrs. P and Ms. S with respect to content coverage fell under this sub node. Throughout her interview, Ms. S returned to her concerns over the fast pace at which she finds herself moving through content in order to keep up with the district's proficiency rubrics, which are organized according to trimester reporting goals:

> *So if, for instance, even now in second grade, you know, we're moving on, we're doing three digit addition and we're moving on. Well if you still don't have your math facts that's a problem being able to continue in that math. Well, can I hold back and say, "Okay, let's hold back, let's all get this under..." I don't have that luxury. [...] that curriculum has to march on.*

Later in the interview, she circled back to the same concern:

> *You know, do I have most kids that can't make a ten? Oh gosh, now I'm really going to have to spend way more time on that. Curriculum demands I need to get on because I gotta cover those other skills.*

Mrs. P shared similar sentiments with respect to time:

> *... the pacing guide and the timeliness of being able to report on this standard at this point, and then the next trimester we add on to it but we have to report on what we didn't finish reporting on, continue reporting on it. And so by the time you're at the end of the year, those kids that are still doing concrete, they've kind of missed out on the new stuff that's coming because you're still shoring up those cheese holes, if you think about Swiss cheese and all the little holes. I try to teach so we don't have holes, but it's the nature of how quick we maybe go.*

Several of Mrs. P's comments with respect to content coverage also touched on the short amount of instructional time for math due to an abbreviated school day (in the study school district, K-3 students are released 45 minutes earlier than older students) as well as to other curriculum requirements and to the many transition times during the day such as specials, lunch, and recess. Ms. S likewise pointed out the shortened school day as problematic, indicating time limited by daily schedule.

For Mr. C, extra planning time was the primary concern with respect to time, although too much content came in second. An extra node by this title was added to the conceptual model to capture responses such as the following:

> *I don't know if I'm necessarily limited on what I can do. I think the struggle of mine is just finding time to make sure that my lessons are as engaging or complete as, or as whole as I'd like them to be. It comes down to a time thing. I mean, you know, it's the grading, the planning...*

Mrs. P also expressed a need for more planning time in her interview. In lamenting her inability to incorporate thematic units into her teaching, she articulated, "it's really hard to find the time to fit that in and logistically have the materials ready for 20 kids in a classroom."

All three teachers also shared a concern over time lost to testing. The early primary teachers were not concerned at all about "teaching to the test" but rather were concerned that time taken up by testing limited their ability to teach for understanding. Ms. S was especially frustrated by the testing requirements in the district. She expounded, "I just question all the testing that we do back to back to back to back. Now I'm three weeks into school and I've hardly taught anything because my days are spent testing."

Time lost to testing and time rushed to cover required content also emerged as themes in the earlier surveys completed by the two early primary teachers. In their surveys, Mrs. P and Ms. S both left comments lamenting the limitations on their time due to the fast pace of the curriculum and the need to use instructional time for testing. In response to an open-ended question prompting teachers to explain some of the factors that inhibit reform instruction, Ms. S wrote, "The lack of time is a huge issue in allowing students to enjoy student centered learning. Curriculum demands as well as testing demands take precedence over best practices." Mrs. P affirmed, "Just time...time to provide quality instruction and learning opportunities. Much of the year feels rushed and teaching time disappears for [benchmark] testing." My researcher memos corroborated this concern with time. After the interview with Ms. S, I recorded the following observation: "Overall I got the impression that Ms. S understands the tenets of student-centered teaching well and would like to teach that way but feels the district's pacing is too fast and testing takes away too much time."

Lack of Procedural Fluency

During her interview, Ms. S discussed the overwhelming number of standard algorithms that must be covered in second grade. When asked what she meant by standard algorithms, Ms. S described the many alternative addition and subtraction strategies incorporated into the mathematics content standards adopted by most U.S. states (for example, using association to make a 10 when adding 8 + 3). She did not feel she had the flexibility to allow students to use and master only those strategies that made the most sense to them but rather needed to cover all of the potential methods since they are incorporated into the district's proficiency rubrics. She opined, "We want them to be able to think conceptually, but in second grade, at this point in second grade, sometimes it is easier to stick with one strategy for a while, and then incorporate another one. You see we have to do it so quickly because we're trying to get that curriculum covered." The passage of text associated with this exchange was double-coded as too much content because it expressed a concern over curriculum requirements rather than with procedures per se. Ms. S was concerned that the sheer number of strategies she had to teach her students was inhibiting their understanding of those strategies that might be the most useful for them in their learning and growth.

Lack of Success on Standardized Tests

Much like Ms. S's concerns over procedures, Ms. S's and Mrs. P's comments with respect to standardized testing had less to do with testing per se and more to do with time lost to testing, which is associated with not covering curriculum content more so than lack of success on standardized tests (as described above).

Mr. C made the greatest number of statements with respect to testing. He does want his students to feel successful on the state-mandated tests they take each year. He was clear to articulate, however, that his concern lies with his students' sense of accomplishment rather than with school rankings or his own job security: "it boils down to the students being successful and them knowing that it was a successful year in what they did to get there." Mr. C did not indicate that test preparation should be a key focus of his instruction but rather agreed that meaningful mathematical tasks would support the strongest learning outcomes in his students.

Lack of Student Understanding and Autonomy

All three teachers shared a strong concern for their students' self-confidence and success in math. Mrs. P and Ms. S made a number of statements expressing a desire to have more instructional time to ensure conceptual understanding before moving on to more abstract or advanced concepts. Ms. S pointed out, "If you don't have any number sense, if you can't put groups together and take them apart, you are lost." Mrs. P noted, "We don't always feel like we have time. We need to learn to give ourselves permission to take the time to do it in the concrete manner before we move to representation, before we move to the abstract." Many of the statements shared in earlier sections that were double-coded as lack of time and too much content were in fact triple-coded as lack of student understanding. In essence, insufficient time to ensure student understanding due to curricular constraints is the primary sentiment arising from the interviews with these two teachers.

Ms. S also expressed frustration with having to introduce children to so many different strategies that she could not allow them to simply stick with the strategies that work best for them before having to teach them another, suggesting that a lack of student autonomy is of concern to her. She pointed out, "When you try to add in all those different ways to do something, sometimes it's not as beneficial as just saying, 'Let's do it this way, this works easiest for you—you're getting the answers correct this way.'"

Personal Values and Expectancy of Success

Notably, none of the teachers exhibited a single personal value associated with traditional instruction in the conceptual model. Although they were not specifically prompted to describe their beliefs about students, the teachers nonetheless shared statements indicating that they believe in their students' abilities to succeed (growth mindset); that students need to build a strong conceptual foundation in math (mathematical knowledge is constructed); and that students should be able to work together and learn from one another. I renamed the node student autonomy is important to student interaction is important to capture the latter sentiment.

Growth Mindset

In discussing the role that standardized testing plays in his instruction, Mr. C commented,

> *first and foremost we want the kids to succeed and feel successful, and see their growth from fall to spring. And, you know, if they see that success and know the hard work, and kind of what they put into that, hopefully that would transpire to future years.*

His primary concern lay not with achieving certain benchmarks for his own benefit or for that of the district—although he did admit to feeling pressure to have his students perform well—but rather for his students' self-confidence in mathematics. He believed that his students could experience significant growth in mathematics and he wanted them to believe the same about themselves; he viewed improvements in their tests scores from fall to spring as an opportunity to bolster this belief.

Both Ms. S and Mrs. P expressed utilizing flexible grouping as opposed to fixed-ability grouping in their classrooms, indicating that they do not track students into "low" or "advanced" levels that might inhibit students' development or self-perceptions. For example, Ms. S explained,

> *Well if I have two or three that I'm like, you know they've mastered that, let's move them on, let's pull back somebody who hasn't. So you see we're constantly making those groups fluid depending on what her needs are, what mine are, who's mastered, who hasn't.*

Mrs. P similarly affirmed, "they would be flexible groups because some kids get certain concepts in some areas as opposed to others. So they wouldn't be stationary groups, or have the same kids all the time." In her earlier survey, she alluded to a belief in every student's potential to succeed: "Instruction needs to meet the learner where he or she is at and move each child forward to reach their individual potential."

Student Interaction is Important

In both her interview as well as her earlier survey, Ms. S expressed confidence in her students' ability to learn from one another and not just from the teacher. When discussing instructional strategies she wish she had more time to implement, she related a scenario in which a child with whom she had been working one-on-one to convey a concept was finally able to comprehend the concept when another child verbalized his thinking during a Number Talk. She concluded, "Kids are powerful teachers to each other." In her survey, she wrote, "It is critical that students have student-centered activities to enhance their learning of math concepts, as well as being able to collaborate with their classmates."

Math Knowledge is Constructed

Both Ms. S and Mrs. P underscored the importance of building a solid conceptual foundation before moving into abstract representations and concepts in mathematics. Ms. S emphasized the importance of getting K-2 students "grounded in number sense" before presenting students with procedures. Mrs. P stated, "when you're teaching K-1-2, we need to have time to build those concepts through concrete experiences."

Revised Conceptual Framework

Figure 2 depicts the results of the data analysis in a revised conceptual framework. In the second iteration of coding, three of the original nodes were renamed and an additional node was created in order to accurately reflect the teachers' sentiments. The term "autonomy" was removed from high self-efficacy and autonomy and from low self-efficacy and autonomy because this wording conflicted with the teachers' interview statements. While the teachers all expressed a strong sense of self-efficacy, they did not feel they had the autonomy to deviate from their district's benchmark standards; hence, statements associated with self-efficacy could not be accurately coded using this node if the phrase "and autonomy" remained in the label.

Initially, the word autonomy was intended to capture findings from the literature suggesting that some teachers do not feel they have the autonomy or authority to deviate from teaching math in traditional ways, which is typically associated with low self-efficacy (Cooney & Shealy, 1997; Cross Francis, 2015; Warfield et al., 2005; Webel & Platt, 2015). Ultimately, this finding can be captured by the term self-efficacy alone (without "and autonomy" tacked on) and/or within the personal values domain under the node math knowledge is transmitted depending on whether a teacher articulates a personal lack of confidence in deviating from traditional instruction (a self-efficacy belief) or whether they feel that it is simply not acceptable to teach math in a more open-ended manner (a personal value).

As noted above, the additional node extra planning time was created to capture statements regarding a lack of sufficient planning time. Student autonomy is important was renamed student interaction is important since this better captures the interview data and better pairs with the binary in the personal values domain teacher authority is important because it suggests that students' knowledge and skills are valued in a classroom and not just those of the teacher. The new title also distinguishes it more clearly from lack of student autonomy in the anticipated costs domain, which refers to statements made regarding student choice in problem-solving approaches.

Nodes in bold font in the revised conceptual framework indicate the most frequently coded nodes while nodes in grey indicate nodes under which no data was coded. All of the most oft-repeated concerns among the three teachers fell under the domain of anticipated costs, while minimal evidence emerged from the interviews suggesting that the teachers held values or expectancy beliefs associated with traditional instruction. Table 1 shows a quantitative summary of the coding outcomes, which informed the visual overlays on the concept map. The highest number of significant passages of text fell within the node not covering curriculum content. In the second cycle of coding, this node was split into three sub nodes—too much content, time limited by daily schedule, and time lost to testing—to distinguish among comments that focused on various constraints on time. It is perhaps fitting that the anticipated costs domain became imbalanced during the coding process, causing asymmetry in the model: indeed, there is clearly an imbalance in many public school systems that causes so many teachers to remain firmly on the traditional end of the instructional continuum despite decades of calls for reform.

Discussion

Why Instruction Falls Short of Reform Recommendations

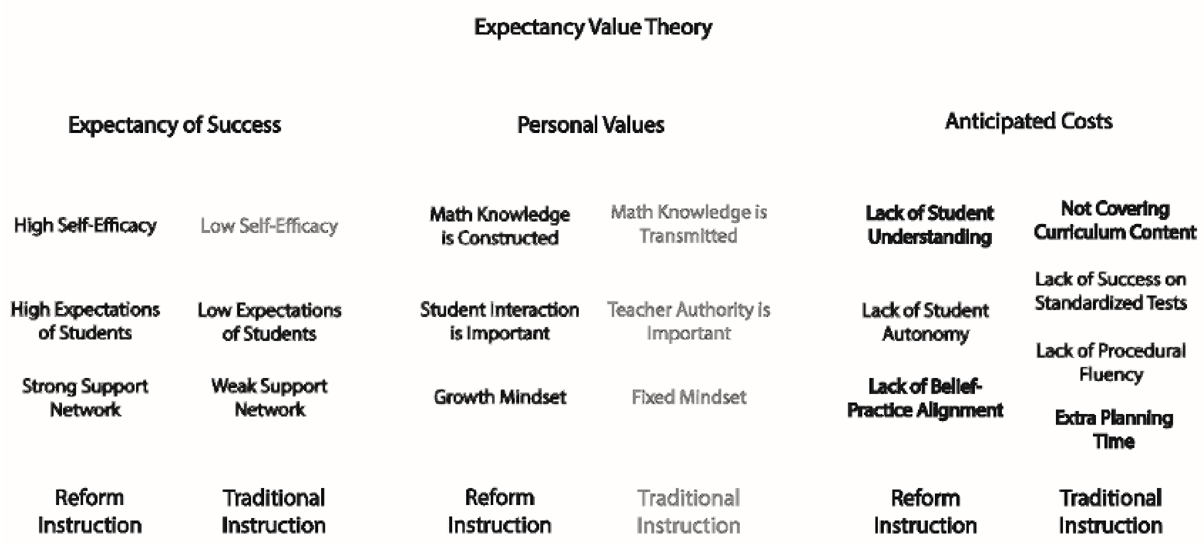
Concerns related to content coverage, procedural fluency, and standardized testing among the three teachers interviewed for this research project all

Table 1
Quantitative Summary of Coded Interview Data

Node	Total Count	Mrs. P	Ms. S	Mr. C
Expectancy of Success:				
High Self-Efficacy	7	3	3	1
High Expectations of Student	7	3	4	
Strong Support Network	5	1	3	1
Low Self-Efficacy				
Low Expectations of Students	1		1	
Weak Support Network	3	3		
Personal Values:				
Math Knowledge is Constructed	5	3	2	
Student Interaction is Important	4		4	
Growth Mindset	6	3	2	1
Math Knowledge is Transmitted				
Teacher Authority is Important				
Fixed Mindset				
Anticipated Costs:				
Lack of Student Understanding	16	4	11	1
Lack of Student Autonomy				
Lack of Belief-Practice Alignment	8	1	4	3
Lack of Success on Standardized Tests	5			5
Lack of Procedural Fluency	1		1	
Extra Planning Time	8	2		8
Not Covering Curriculum Content				
Too Much Content	19	5	11	3
Time Limited by Daily Schedule	4	2	1	1
Time Lost to Testing	4	1	2	1

Note. *Ms. S's interview lasted twice as long as the interviews with Mrs. P and Mr. C.*

Figure 2
Revised Conceptual Model



coalesced around a single shared theme: time. None of the teachers were explicitly concerned with test preparation or procedural fluency per se. The kindergarten and second-grade teachers both felt that they did not have sufficient time to cover all of the required content included in their district's benchmarks in the hands-on way most meaningful to young learners. They felt that testing took up too much instructional time, compounding the struggle to provide adequate time to learn concepts on a conceptual level. The fifth-grade teacher, while more sympathetic to the benefits of standardized testing, also felt that testing time frames impinged on his ability to map out his curriculum in a more optimal manner; end-of-year testing occurs in April, forcing certain concepts to be covered more than a month before the school year comes to a close. He also felt that his school day did not include enough time for him to plan for more robust math instruction.

While Abrami et al. (2004) found the expectancy of success component of EVT to be the most significant predictor of using or not using cooperative learning -in their study, teachers who did not use CL reported low student expectations- in this study the cost construct seemed to weigh most heavily on the teachers' instructional choices. All four of the most salient nodes in the interview data fell within this construct. The teachers in this study did not appear to lack self-efficacy or a belief in their students' abilities to engage in reform instruction. To the contrary, they believed that students learn best from hands-on experiences and student-to-student interaction and they expressed concern over having to limit these practices. The cost of students not fully understanding the mathematics they are supposed to be learning was of great concern to these teachers. However, this cost was outweighed by the time cost associated with implementing reform instruction and the need to meet certain benchmarks by certain time points during the school year. All three of the teachers reported having insufficient instructional and/or planning time to maximize their students' understanding of mathematics, at least not without sacrificing coverage of the content included in the district's proficiency scales.

Using Expectancy Value Theory to Study Instructional Decision-Making

In addition to exploring reasons why K-5 teachers find it difficult to implement math instruction that lies firmly on the reform end of the instructional continuum, this study sought to investigate the use of Expectancy Value Theory to frame research on teachers' beliefs and practices. The EVT framework proved to be an extremely helpful and relevant tool for doing so. All salient remarks made by the teachers during their interviews aligned well with one or more of the constructs embedded in the framework, much as Abrami et al. (2004) found in their quantitative study, which greatly facilitated the coding process. With adjustments made during data analysis, the EVT framework accurately captured both the personal and contextual factors influencing the teachers' instructional decisions.

The different findings arising from the present study and from Abrami et al. (2004) suggest that variables impacting instructional decision-making vary from context to context and that supporting reform instruction requires localized rather than one-size-fits-all approaches. Other educational researchers and those responsible for generating professional development opportunities might adapt the EVT framework developed for this study to identify the variables most salient to the contexts within which they are working in order to tailor reform efforts to the needs of the teachers in their districts. Teachers holding low expectations of students and disbelieving that mathematical knowledge can be constructed would require an entirely different form of professional development than teachers who believe in the abilities of their students to construct their own knowledge but who feel constrained by other factors. Survey items or focus group questions could be developed to capture teachers' sentiments with respect to the domains and constructs embedded in the model—much as Abrami et al. (2004) did for their study—to inform decisions associated not just with professional development but also with curricula, scheduling, and other factors that impact teachers' day-to-day instruction.

Implications for Reform

Although the findings from Abrami et al. (2004) indicate that expectancy of success is important—a teacher that does expect to succeed with reform instruction will not use it—the present study suggests that reform values may not be sufficient to promulgate meaningful reform. As evidenced by the concept map in Figure 2, a majority of the interview data indicate that the teachers in the study would be expected to engage in reformed math instruction based on the alignment of their values and expectancy beliefs with reform-oriented characteristics identified in the literature; however, the teachers all felt constrained in their ability to do so.

An important finding from this study is that even when teachers hold expectancy beliefs and personal values in line with reform instruction, school contexts may nonetheless inhibit their ability to implement reform practices. The teachers in this study are not teachers who are making excuses based on low self-efficacy or low expectations of their students, as teachers in other studies have expressed (Abrami et al., 2004; Rousseau, 2004; Thompson, 1984; Warfield et al., 2005). To the contrary, all three teachers exhibited confidence in their abilities to teach students for understanding—given the freedom to do so—and articulated a clear understanding of the reform instruction advocated by NCTM. In their interviews, each teacher alluded to one or more best practices such as flexible grouping, students learning from students, using concrete representations to build conceptual understanding, and creating coherent lessons that address whole concepts and not just procedures. They reported using many of these practices themselves—but not to the extent that they would like to.

Areas for Future Research

The findings raise important questions for further research. First and foremost, it is imperative to continue to explore the role that professional duties and obligations play in limiting teachers' ability to implement reform recommendations. Many studies have suggested that high expectations of students and strong self-efficacy are characteristics that lend themselves to more reformed instruction (Abrami et al., 2004; Smith, 2012; Stipek et al., 2001; Warfield et al., 2005). However, the teachers in the present study expressed such enabling beliefs but nonetheless felt constrained in their practice, as other researchers have also found (Stemhagen, 2011; Webel & Platt, 2015; Yurekli et al., 2020).

In one study, Smith (2012) found that a particular teacher was able to implement reform practices despite an institutional context that seemed to constrain the other teachers in the study. Unlike her peers, the reform teacher did not allow herself to feel limited by the district pacing and curriculum guides. Why did the teacher in Smith's study experience such autonomy while the teachers in the present study, who shared many of the same characteristicsm -high expectations of students, strong self-efficacy, and a desire for students to make sense of math for themselves- did not? Further research should examine teachers in various school settings in order to identify factors that enable educators to successfully implement reform even when faced with contexts that seem to inhibit other teachers.

Future research could also help to determine whether the differences observed between the kindergarten and second-grade teachers on the one hand and the fifth-grade teacher on the other hand are due to age, gender, teaching experience, the grade level taught, or to a combination of these or other factors. Indeed, the fifth-grade teacher's concern with students' performance on standardized tests aligns with findings associated with other fourth- through eighth-grade teachers in a quantitative belief-practices study conducted by Yurekli et al. (2020), whereas the early primary teachers, who did not express concern over performance on standardized tests, diverged from these findings.

Limitations of the Study

This study focuses on just three teachers from a single school district in the United States. Further research involving secondary teachers as well as teachers in different settings would expand our understanding of the beliefs and motivations that influence teachers' instructional choices from an EVT perspective. A limitation of the study is that it did not include classroom observations to corroborate the teachers' interview data. Cross Francis et al. (2015) note that self-reported data is problematic in teacher-beliefs research due to the potential for biased results. However, the study was specifically designed to address one of the primary concerns identified by the authors: "scales are constructed to assess mathematics beliefs while teachers' actions are often motivated by factors beyond beliefs about mathematics" (Cross Francis et al., 2015, p. 348). A primary goal of the study was to investigate the interaction between beliefs and motivations linked to school contexts, such as standardized testing and pacing guides, utilizing a framework that enabled factors other than just beliefs to emerge from the analysis. Teachers were in fact not directly asked about their beliefs; instead, their beliefs were surmised from the statements they made in the course of talking about their frustrations in trying to implement reform instruction within the constraints of their teaching contexts.

Conclusions

Although this research represents a single case study, the results raise important questions when contrasted with the larger-scale quantitative study conducted by Abrami et al. (2004). The present study confirms the utility of Expectancy Value Theory as a framework for examining teachers' beliefs and motivations and extends its application to qualitative approaches. Yet the study also challenges findings from Abrami et al. by suggesting that the cost component of the model, as opposed to expectancy of success, may weigh more heavily in teachers' instructional decision-making in certain contexts. Further research is needed to continue to explore the cost-benefit analyses that teachers make in determining whether, and to what extent, to adopt reform practices.

A major finding from this study is that teachers with a strong understanding of reform instruction and with personal beliefs supporting reform practices may nonetheless feel limited in their ability to implement these practices given the amount of content they must cover and the instructional time lost to testing. Many of today's teachers are operating in a "contradictory environment" in which they are being prodded to embrace reform instructional practices without the support of accompanying reforms in district-wide curriculum and assessment practices (Yurekli et al., 2020, p. 245). Researchers, policy makers, and school leaders wishing to foster a greater use of reform instruction would be wise to carefully analyze the policies, benchmarks, curricula, and testing requirements currently in place in public schools to look for ways to grant teachers more instructional time and freedom to hit key concepts at greater depth. The national standards in the United States, the Common Core State Standards for Mathematics, are built on a foundation of solid number sense; if that foundation is not in place, then expected outcomes associated with the standards will not be realized.

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Developing Children's Computational Thinking through Physical Computing Lessons

Sun Hee Min[a], Min Kyeong Kim[*,b]

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[a] Sun Hee Min. Department of Elementary Education, Ewha Womans University, Seoul, Korea.
E-mail: sunnym73@naver.com
ORCID: http://orcid.org/0000-0002-4715-8978

[*,b] **Corresponding Author:** Min Kyeong Kim. Department of Elementary Education, Ewha Womans University, Seoul, Korea.
E-mail: mkkim@ewha.ac.kr
ORCID: http://orcid.org/0000-0002-6788-9890

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Abstract

In this study, we designed and applied physical computing lessons for elementary 6th-grade students based on the software education guidelines in the Korean 2015 Revised National Curriculum (Ministry of Education, 2015a). The participants of this study were ten 6th-grade students of an elementary school in Gyeonggi-do province in Korea. The physical computing lessons used in this study supported the active interaction of the digital world and the physical world by constructing a physical model using specific media, and controlling it with a program. In order to understand the changes in the students' computational thinking after the class, we analyzed these changes in terms of computational concept, computational practice, and computational perception. Research has shown that physical computing lessons materialize students' computational concepts through computational practices, and improve their computational perspectives through the use of authentic contexts. We expect that the physical computing lessons and analysis tools developed through this study will provide educational implications for future software education.

Keywords:
Computational Thinking, Computational Concepts, Computational Practices, Computational Perspectives, Physical Computing, Elementary Education

Introduction

Computer science plays a vital role in today's technologically and globally connected world. Thus, it is essential to introduce computing ideas to students early in their schooling (Yadav, Hong, & Stephenson, 2016). To prepare for this social change, countries such as the United States, the UK, Australia, India, and Israel view computational thinking as a key competency that future generations should possess and be able to apply to various subjects, such as mathematics and science (Ryu & Han, 2015). The school environment has a uniquely large impact on future generations, as educators continuously prepare their students for technology-driven futures (Griffths, Nash, Maupin, & Mathur, 2020).

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Papert (1996) first introduced the concept of computational thinking, while Wing (2006) later defined it as a fundamental ability that allows people to design and think using the language of computation. In other words, computational thinking involves numerous skills, such as logical thinking, algorithm selection, and systematic thinking, which can be used to solve problems in a variety of learning contexts and in daily life, not only in professional computer science fields (Tsai, Wang, & Hsu, 2019). Denning (2005) suggested that computational thinking today includes the use of abstraction, mathematics for algorithmic development, and efficient problem solving.

In this regard, the Korean Ministry of Education (MOE, 2015b) emphasizes the importance of software education in the formal curriculum with the goal of strengthening competence, including information ethics and attitudes, while presenting computational thinking as a key competency of software education. For elementary school, the Ministry proposed expanding and reorganizing the existing contents of the Information and Communication Technologies (ICT) application into basic software literacy education (MOE, 2015a). Educational programming languages have been applied to this end (Song & Gil, 2017; Shin & Bae, 2015). Other tools include robots (Marion et al., 2017) and various types of educational media as physical computing tools (Alimisi, 2013; Bakke, 2013; Chandra, 2010; Felica & Sharif, 2014; Kim & Kim, 2016; Resnick, 2006).

Since 2019, software education has primarily been taught in grades 5 to 6, and efforts are under way to address the lack of learning time to cultivate the core competencies of software education (Han, Cheong, & Lee, 2017). To address the limited amount of available class time, which is a significant problem facing those who design computing lessons, some authors have studied computing not solely as a practical subject (Kim, 2015; Ryu & Han, 2015), but in relation to other subjects, such as mathematics and social studies (Shin, Cho, & Kim, 2013), as well as methods of applying it to different creative activities (Kim, 2015; Kim, Kim, & Ryu, 2013; Song, 2013). In addition, researchers have designed educational programming languages, such as Scratch and Entry, and various physical computing tools and software to enable students to learn through experience, considering the developmental level of elementary school students (Anglei et al., 2016; Kim & Lee, 2014)

Therefore, in order to implement software education, it is necessary to study educational media and various evaluation methods and to introduce different types of content. In particular, because computational thinking is emphasized as a core competency of software education, research is needed on how students express computational thinking, and how they can be evaluated. However, considering the limitations of approaching only the cognitive aspects of computational thinking (Kim, 2009), or of evaluating it as a learning output (Seiter & Foreman, 2013), it is necessary to study various aspects of how students understand computational concepts. For example, students must not only know the concepts, but also find the changes of computational concepts in practice. This means approaching computational thinking as a process of problem solving (Wiggns & McTighe, 2005; Bers, 2010; CSTA, 2012; Denning, 2017; Wing, 2006), in the sense that a concept is only meaningfully learned when a student can use it to solve a unique problem.

To consider computational thinking in terms of the harmony of thinking and computing technology, it is necessary to examine students' computational concepts in actual computational practice. In physical computing lessons, activities that explore changes in behavior using programming and robots are expected to help students shape computational thinking through the harmonization of concepts and practice by implementing students' ideas through computing technology. In addition, in order to continuously demonstrate computational thinking, it is necessary that students' active attitudes change through recognition conversion. Therefore, by assessing changes in computational perspectives in the classroom, we expect that this work will have implications for strengthening the attitude and capacity emphasized in software education. In addition, the appropriate result can be benchmarked against the relevance of ICT use within the wider personal, cultural, social and psychological context of a person's daily life (Talaee & Noroozl, 2019).

Therefore, in this study, we aimed to analyze the characteristics of computational thinking by designing physical computing lessons and applying them to elementary school students. In addition, we looked at the changes and features in computational concepts, computational practices, and computational perspectives in order to examine various aspects of computational thinking through physical computing lessons. In order to support the development of computational thinking, we provide concrete instructional design and application for physical computing lessons, implications for evaluation, and ideas for follow-up research.

The following research questions guided this study:

1. How was the physical computational class designed for elementary school students?

2. How did computational thinking appear to elementary school students who experienced the physical computing classes?

Research Background

Physical Computing

For more than 30 years, constructionist tool kits, robotics, and physical computing kits have been present in educational contexts (Przybylla & Romeike, 2014). As Resnick (2007) observed, "In today's rapidly changing world, people must continually come up with creative solutions to unexpected problems. Success is based not only on what you know or how much you know, but on your ability to think and act creatively." In this respect, the physical computing tools that connect the digital world with the real world are expected to provide students with creative experiences for problem solving.

Physical computing covers the design and realization of interactive objects and installations, and allows students to develop concrete, tangible products that arise from the learner's imagination. This can be used in computer science education to provide students with interesting and motivating access to the different topic areas of a subject in constructionist and creative learning environments (Przybylla & Romeike, 2014).

The physical computing environment uses sensors and actuators that can replace the human senses. A microcontroller can be used as a learning medium that is capable of robot programming (Kim & Kim, 2016; Seo & Kim, 2016).

Physical computing tools can be divided into robot, board, or modular types. In the case of robot type tools, a physical output device, such as a motor, is reinforced. Programming allows us to move robots and control output devices, such as sounds or lights, and if sensors are used, we can interact with the real world, such as by following lines or avoiding obstacles. Board type refers to electronic boards including microcontrollers. Because it is necessary to understand electric circuits and apply electronic knowledge, it is not easy to apply this type of robotic learning in elementary school classes.

Finally, modular type means that various input and output devices are assembled, connected to a microcontroller, and controlled using an educational programming language. Ultimately, students will be able to experience the process of designing, building, and programming their own robots. The modular type has the advantages of both robot type and board type, and it can help give learners practical experience, which can aid them in finding ideas and solutions for real life problem solving.

The use-modify-create model (Lee et al., 2011), a learning model for software education, emphasizes learning by making through hands-on experience. In particular, the authors of the model pointed out that environments should encourage active learning through play. The model also emphasizes that learners should experience inventions, rather than imitations or implementations of algorithms (Futscheck & Moschiz, 2010).

Physical computing takes computational concepts into the real world, so students can use those concepts in authentic environments. Physical computing activities are strongly connected to the dimensions of computational thinking, namely, abstraction, algorithmic thinking, automation, decomposition, debugging, and generalization (Psycharis et al., 2017). Sometimes, digital making is also referred to as tangible programming (or physical computing, digital fabrication, or creation of graspable user interfaces). Digital making is simultaneously a tangible representation of digital CT that moves beyond text-based computer programming and coding (Kotopoulos et al., 2017).

Physical computing is a form of computing science that is connected to the arts, which leaves a great deal of room for creative work in the classroom. Additionally, physical computing allows for various connections to other STEM subjects; for example, simulation of behavior relates to biology, collection and analysis of measurements relates to physics, and logical operations relate to mathematics (Schulz & Pinkwart, 2015). Ongoing research aims to determine the effects of physical computing on students in computer science classes by investigating its impacts on students' motivation, creativity, constructionist learning, learning success, growth in competences, and understanding of computer science and computing systems (Przybylla & Romeike. 2014).

Kabátová and Peárová (2010) suggested certain points to consider when designing a class. For example, activities with robotic models, programmable kits, and toys are good opportunities to organize the lessons in a constructionist way. The constructionist ideas and principles (Papert, 1999; Rusk et al., 2008) we promote in our lessons are:

- learning by doing, genuine achievement, hard fun and playful learning, learning through designing,
- technology as building material combined with artistic materials, and
- taking time, freedom to make mistakes, teamwork.

Taken together, physical computing that can take advantage of tools, including board, modular, and robotic type tools, can help students learn by building physical systems that connect the physical and computing worlds. Robotics exemplifies an appropriate use of technology to create meaningful, open-ended, problem-solving activities (Felica & Sharif, 2014). In addition, lessons that use physical computing tools provide opportunities for students to understand abstract concepts through realistic experiences, support students in shaping their ideas, and facilitate communication and the fostering of social skills.

Computational Thinking

Regarding computational thinking, Wing (2006) outlined the basic skills necessary for all people living in the 21st century, such as reading, writing, computation, and using computing technology to solve problems. She also emphasized that abstraction and automation are key elements of computational thinking. Computational thinking uses abstraction and decomposition to attack a large, complex task or design a large, complex system. Computational thinking is a fundamental skill for everyone, not just for computer scientists; and to reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability (Wing, 2008).

Bers (2010) defined computational thinking as a type of analytical thinking that has many similarities to mathematical thinking (e.g., problem solving), engineering thinking (design and evaluation processes), and scientific thinking (systematic analysis). The term grew out of the pioneering work of Papert and colleagues on design-based constructionist programming environments; it refers to ways of algorithmically solving problems, and to the acquisition of technological fluency (Papert, 1980).

Yadav, Hong, and Stephenson (2016) emphasized the importance of thinking to all students by suggesting algorithms, abstraction, and automation as key elements of computational thinking. The authors also emphasized that teachers' understanding of computational thinking is essential for incorporating it into the classroom environment.

The essence of computational thinking involves breaking down complex problems into more familiar/ manageable sub-problems (problem decomposition), using a sequence of steps (algorithms) to solve problems, reviewing how the solution transfers to similar problems (abstraction), and finally determining if a computer can help more efficiently solve those problems (automation). These computational thinking steps are foundational to computer science, but their power and utility extend far beyond any single discipline. We believe that the computational thinking ideas outlined in this paper are key to moving students from merely being technology literate, to using computational tools to solve problems and represent knowledge. Developing teachers' understanding of computational thinking and highlighting connections to their curricular context is key to successfully embedding computational thinking in K-12 classrooms. Tedre and Denning (2016) pointed out that CT as a concept has been studied for a longer time than suggested by Wing (2006), and it is necessary to know about problems, ideas, and risks that have already been solved during this history of CT. Also they examined a number of threats to CT initiatives: lack of ambition, dogmatism, knowing versus doing, exaggerated claims, narrow views of computing, overemphasis on formulation, and losing sight of computational models.

Brennan and Resnick (2012) suggested a way of approaching the three aspects of computational thinking in a study using Scratch. Having articulated the framework for computational thinking (concepts, practices, and perspectives), they described three approaches to assessing the development of computational thinking in young people who are engaging in design activities with Scratch. Computational practices focus on the process of thinking and learning, moving beyond what the students are learning to how they are learning

Table 1
Strength and Limitations of Assessment Approaches

Approach	Concepts	Practices	Perspectives
Approach #1: Project Analysis	Presence of blocks indicates conceptual encounters	N/A	N/A (possibly by extending analysis to include other website data, like com-ments)
Approach #2: Artifact-Based Interviews	Nuances of conceptual understanding, but with limited set of projects	Yes, based on own authentic design experiences, but subject to limitations of memory	Maybe, but hard to ask directly
Approach #3: Design Scenarios	Nuances and range of con-ceptual understanding, but externally selected projects	Yes, in real time and in a novel situation, but externally selected projects	Maybe, but hard to ask directly

(Brennan & Resnick, 2012, p. 22)

(Brennan & Resnick, 2012). Table 1 shows the limitations of each method of analyzing computational thinking.

Alternatively, researchers have also conducted studies on computational thinking in terms of subject and problem solving. Weintrop, Beheshti, Horn, Orton, Jona, Trouille and Wilensky (2016) discussed the definition and characterization of computational thinking in secondary mathematics in conjunction with STEM education.

Methodology

Lesson Design

In this study, to assess students' practical understanding, we analyzed computational thinking centering on the computational practices that appeared in class. To this end, a learning environment in which the students' own ideas could be manifested was provided by utilizing physical computing tools that support active interaction between the physical and computing environments.

In these physical computing lessons, the subject, content, and evaluation method were designed to teach the algorithms and programming areas emphasized in the guidelines for software education (Ministry of Education, 2015b) based on the use-modify-create model of robots (Lee, Martin, Denner, Coulter, Allen, Erickson et al., 2011).

Furthermore, the "Maze Escape" and "School Bus" lessons were developed and applied in conjunction with mathematics and social studies concepts. The classes explored the core concepts, factual content, and achievement skills of elementary school practical art subjects. In order to develop the subjects of the lessons, a preliminary study was conducted on four 5th graders and twenty 5th – 6th graders over the course of one year. In addition, whether real life application, inquiry, enjoyment, and cooperation were possible (Shin & Bae, 2014), and whether it was possible to connect with different regions (Choi, Choi, Ahn, Hong, & Jung, 2015) were all considered.

Participants

The subjects of this study were ten male 6th grade elementary school students in Gyeonggi-do province, Korea, who participated in the class voluntarily after being informed of the purpose of this study in advance. Before the students participated in the class, a separate introductory session was used to explain the purpose and contents of the study, and consent forms were used to obtain the student's and guardian's signatures. Physical computing lessons were held every Friday for a total of six sessions, 80 minutes per session; before each class started, 80 minutes of extra time was provided to help students understand the medium. The physical computing tool used LEGO bricks to assemble the body of a robot.

Data Collection & Analysis

In this study, quantitative and qualitative data were collected in order to analyze changes in students' computational practices following physical computing lessons. The main researcher participated in the research, introduced class topics, and observed the students' problem solving process; she also played the role of a teacher in assisting the study participants with overcoming any difficulties experienced during the physical computing lessons. In addition, the students' normal teachers were encouraged to help with class recording and collection of various materials. The rubrics and test tools used in the research process were revised and supplemented based on the results of the preliminary study through consultations with experts in elementary education and robotics education, and elementary school teachers.

Data collection was carried out through a computational concepts test conducted before and after class, observation of class participation, interviews, activity sheets, and anecdotal records. For data analysis, quantitative and qualitative analyses were performed using a hybrid research method to grasp the computational thinking of students who applied the physical computing lessons.

For the quantitative analysis, computational concepts test scores, worksheets, and interviews conducted using a computational practices rubric, as well as data collected through anecdotal records, were statistically analyzed. For the qualitative analysis, we attempted to understand students' computational thinking processes by observing students' participation in class, interviewing the students, and analyzing outputs and activities. In addition, a single case study was conducted to assess changes in individual computational thinking, and we attempted to explore certain aspects of computational thinking in detail through individual examples of how computational concepts, computational practices, and computational perceptions appear in physical computing lessons.

Assessment 1: Computational Concepts

The UK Bebras Computational Challenges (2015) is an online competition open to students in the UK and English-speaking international schools around the world; it requires intelligence, but no previous knowledge. The hope is that the competition will increase youngsters' general interest in computer science and help them to understand that computational thinking has far-reaching applications in solving all sorts of life's problems.

In the computational concepts test, a pre-test and post-test were conducted using the same question; no answer to the test question was provided. It was conducted at 2-month intervals, including the class time between the pre-test and post-test. To measure computational concepts, the participating students had 40 minutes to solve 15 questions. However, when we scored their work, we did not use the additional scoring rubric as required by the UK Bebras Computational Challenges. Instead, correct answers received 1 point, and incorrect answers received no points (i.e., points were not deducted for incorrect answers). The post-test Cronbach's alpha for computational concepts excluding items 3 and 9 was .764.

Assessment 2: Computational Practices

To assess computational practices, we reconstructed the relevant rubric based on the three areas of experience—problem-solving, algorithm, and programming—presented in the MOE's Software Education Guidelines (MOE, 2015b). We evaluated the experiential domain of the problem-solving and algorithmic processes using revised rubrics based on Choi (2014) and Brennan, Balchm, and Chung (2015), respectively. We reconstructed the programming experience area by referring to the robot design rubric of the For Inspiration & Recognition of Science & Technology LEGO League (2015).

We also conducted interviews with the students based on Brennan and Resnick's (2012) observation that it is difficult to evaluate computing practices solely by analyzing output. The interview questions gauged how students understood and structured the problems, searched for solutions, and understood the role of programming in class activities. Students introduced their projects and explained their problem solving methods and the ideas or people who helped them. In addition, they explained the differences between how to program, and how to apply and explain the commands and solutions. To help students remember, the interviewer used their own output as an example. Table 2 shows some interview items that were used to evaluate computational practices.

Based on the actual experiences of the students themselves, we conducted two interviews using the students' outputs immediately after the end of each activity topic, considering the limitation of memory. We analyzed the reliability of the three graders in the scoring of the students' computational practices. Table 3 presents the inter-scorer reliability, assessed using Pearson's correlation coefficient.

Assessment 3: Computational Perspectives

Brennan, Balchm, and Chung (2015) divided computational perspectives into three areas: expressing, connecting, and questioning. They analyzed computational perspectives by looking at students' perspectives of physical computing lessons (perspectives of expression, cooperation, and use). For this study, an anecdotal record consisted of two narrative questions and five multiple choice questions, and students wrote anecdotes for each class.

Table 2
Interview Items for Evaluating Computational Practices

Strands	Interview details
Understanding and structuring the problem	Introduce your project.
Searching for problem solutions	How did you solve the problem? Did you have any ideas or people who helped you solve the problem? Have you made any changes in today's activity? Why did you fix it like that? Describe how you tried to solve the problem.
Understanding programming	How did you program it to solve the problem? What commands did you use? Please explain the commands used. Was there a difference between what you expected, and what was real?

Table 3
Inter-Scorer Reliability: Computational Practices

Items	Activity themes	A–B	A–C	B–C
Worksheets	#1 Maze Escape	.994**	.797**	.833**
	#2 School Bus	.748*	.795**	.808**
Interviews using outcomes	Total	.934**	.911**	.875**

*** p < .01*

Results and Discussion

Physical Computing Lessons

We conducted each physical computing lesson three times, centered on two themes, maze escape and school bus. Based on the practical subjects of the curriculum, which was last revised in 2015, the subjects of mathematics and social studies were linked to each other. We considered whether a topic was explored, used in daily life, facilitated cooperation, or caused pleasure (Shin & Bae, 2014), whether the use–modify–create model (Lee, Martin, Denner, Coulter, Allen, & Erickson, 2011) or the algorithmic invention model (Futscheck & Moschiz, 2010) could be applied, and whether the lesson could be connected with the community (Choi et al., 2015). Table 4 shows the contents of the lessons and activities conducted in this study.

The main activity of the physical computing lessons was to create and program robots; this allowed students to invent algorithms through experience. First, in the "Analyze problem" stage, the students identified a problem and clarified that problem by analyzing the given situation and conditions; at this point, the students removed any unnecessary information from consideration. Second, in the "Find ideas" stage, the students collected data and generated various ideas to identify the best ones; in addition, we constructed robots, identified the properties of the media, and collected ideas for problem solving. Third, in the "Formulate algorithms" stage, we designed a method of realizing an idea and designed a concrete process that included a program to specify the necessary algorithm. Fourth, in the "Play algorithms" stage, the program was tested based on each algorithm. Fifth, in the "Reflect algorithm" stage, problems were identified and corrected while the results were evaluated. Students checked their problem-solving processes and algorithms to find and fix errors. They also shared their results and conducted self- and peer evaluations in order to objectively view their own output. The students produced robots as a means of solving problems by programming and experimenting in teams of two. The students built and moved the robot themselves, embodied their ideas with algorithms, and debugged their programs through execution. Real life-based problematic situations helped students immerse themselves in the learning process, and easy-to-edit robots and programming tools helped students to check their ideas. Figure 1 shows the robot and maze used in class.

Students observed the maze, moved like a robot, and discussed their ideas with other students. In addition, the discussion was organized using pictures, texts, and symbols. Students acted like robots, extracting the elements necessary for movement, understanding problems, and finding ideas. Through this process, the robot's behavior was sequentially arranged, and each algorithm was created. The students' algorithms were embodied through programming, and modified and supplemented through practice. Figure 2 illustrates the students' ideas that allowed the robot to escape the maze.

Table 4
Physical Computing Lessons: Contents and Activities

Lesson steps	Activity themes	
	#1. Maze Escape	#2. School Bus
Analyze problems and find ideas	Make robots using basic building instructions Explore robot movement	Build a town map and school bus, share ideas, and make a plan with peers
Formulate and play algorithms	Modify robots, get directions using robots, programming, and testing	Recreate school bus, do programming and test
Play and reflect algorithm	Execute maze escape	Optimize school bus movements

Figure 1
Students' Robot and Maze Escape Activities

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Figure 2
Students' Ideas for Escaping The Maze

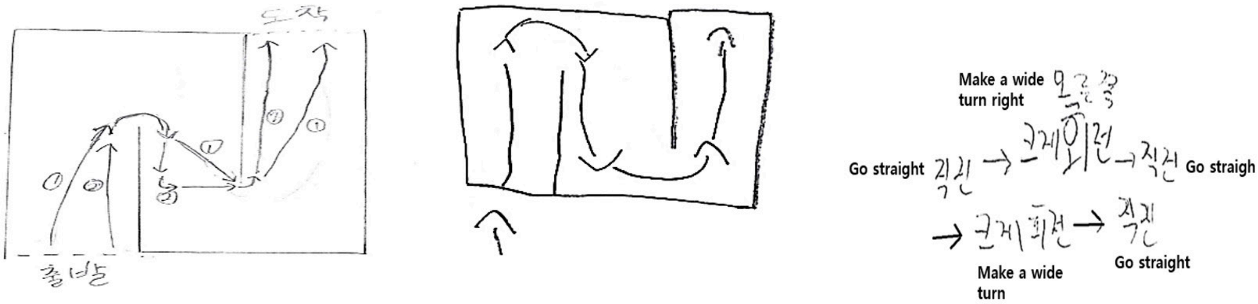
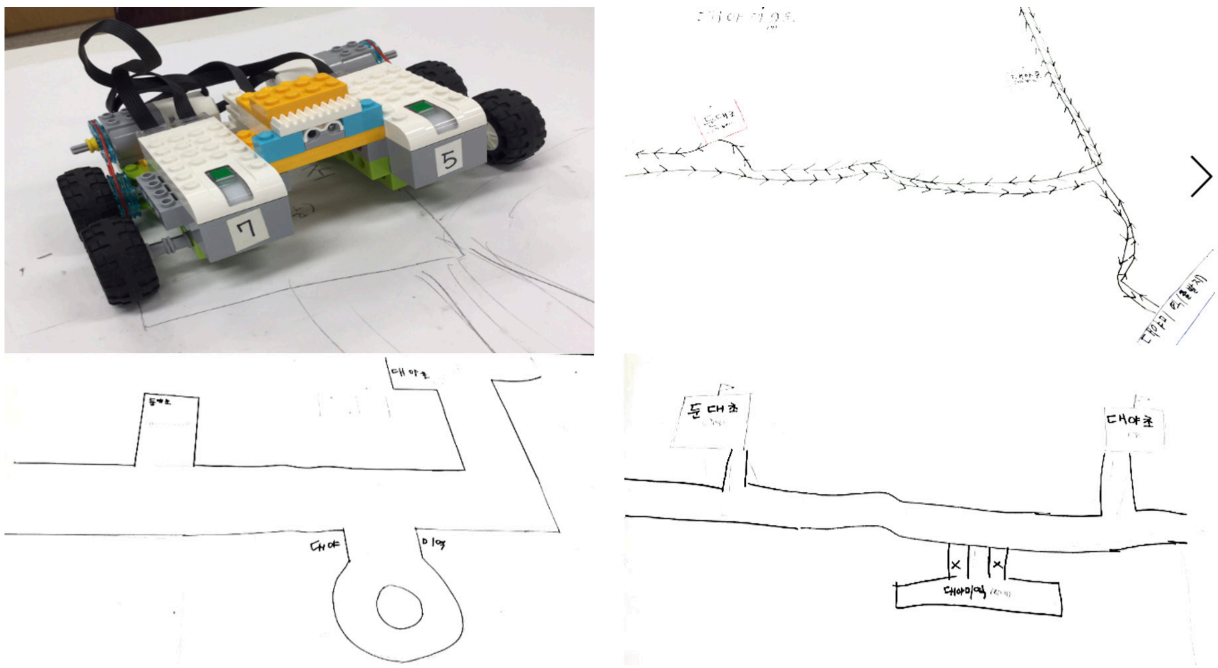


Figure 3
Students' Outcomes: School Bus Robots and Students' Maps



In the maze escape class, the students used a basic type of robot to allow them to focus on algorithms and programming strategies. In order to move through the maze, the students modified the robot in their own ways. The maze was divided into two stages, which were delineated by a middle point and a final goal point, so the students could solve the task step-by-step. This activity used assembly diagrams to create and test basic models, so the students were able to focus on programming. In addition, the students connected their two robots according to their own ideas. The students used the command function to control the robot by specifying each movement of the robot as an action. In particular, to move the robot, it was given a command to forward, reverse, or change direction. To this end, the students identified a method of controlling the motor connected to the wheel. The mission to go through the maze continuously challenged the students to solve problems and made them feel as if they were the real drivers of the robot.
In the school bus class, the students created a school bus (robot) that could solve a problem in their local neighborhood. Students made a school bus and created a map that connected two schools and subway stations in the areas where they lived. Students created robots by adding their own ideas on top of the basic robot model they had experienced in the maze activities. The robot was programmed to drive on the road that they mapped. Figure 3 shows the robots and maps that were used in class.

This class consisted of 3 lesson stages per activity, and lasted for 80 minutes per lesson stage. In the first stage, the students analyzed problems and came up with ideas to address those problems. In the second stage, the algorithm was formulated and executed, which was accomplished by converting each algorithm into a program. The 3rd stage consisted of performing and reflecting algorithms. At this time, self-evaluation and mutual evaluation were conducted while observing the movement of the robot. Figure 4 presents the problem-solving structures of the maze escape and school bus classes.

Computational Concepts

To analyze the changes in computational concepts of the students who participated in the physical computing classes, we administered the UK Bebras Computational Challenge (2015) questionnaire before and after the class, and statistically analyzed the results. Each item on the questionnaire is based on five elements: abstraction, evaluation, generalization, decomposition, and algorithmic thinking of the computational concept. The computational concept test consists of a total of 15 questions, each of which are assigned one point; the maximum score is 15 points.

The computational concept test results revealed a difference between the pre- and post-intervention scores of -3.074 at $p = .013$, a statistically significant difference at $p < .05$ (see Table 5). In short, following the physical computing lesson, the students showed an improved understanding of computational concepts.

To fully understand the changes in the students' computational concepts, we extracted scores for algorithmic thinking, abstraction, and decomposition, which are the elements of automation that scholars commonly highlight as core elements of computational thinking. Table 6 shows the components and difficulty of each item.

Among the problems with high difficulty level, on the robot painting problem, the students showed nearly twice the number of correct answers on the post-test vs. the pre-test. For the monster problem, they had more than double the number of correct answers on the post-test. The results showed that the physical

Figure 4

Flow Charts: Maze Escape (Left) and School Bus (Right)

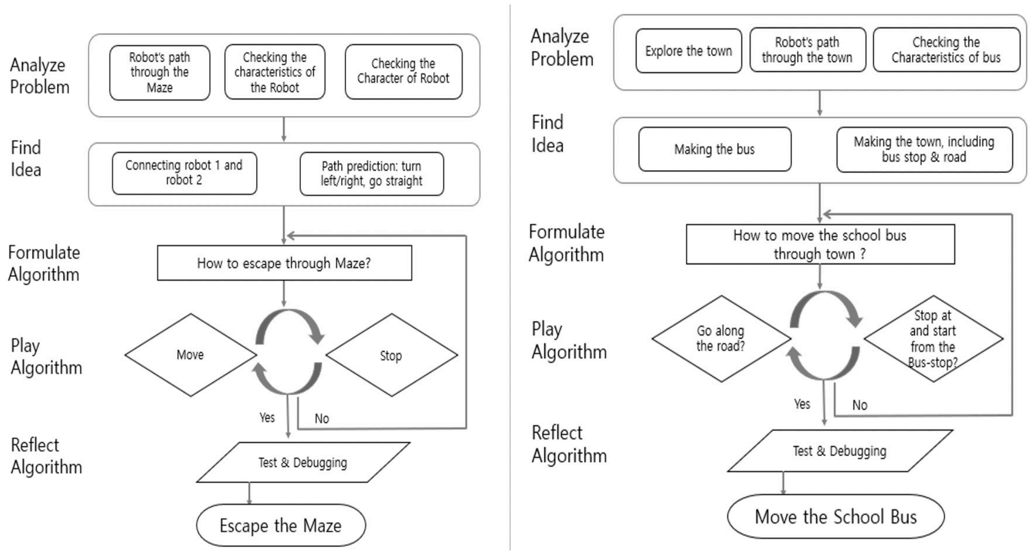


Table 5

Computational Concepts Test Results

	M	*SD*	cases	*t*	*p*
Pre-test	8.80	2.485	10	-3.074	.013*
Post-test	10.10	2.514	10		

* $p < .05$

Table 6

Computational Concepts: Algorithmic Thinking

Problem	level	Algorithmic thinking	Abstraction	Decomposition	Testing results		Variation
					Pre-test	Post-test	
Watering	low	•			10	10	0
Tic Tac Toe	middle	•	•		10	10	0
Abacus		•	•	•	8	9	+1
Village Network		•	•	•	8	7	-1
Drawbot	high	•	•	•	3	5	+2
Monster		•	•	•	3	7	+4

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computing lesson helped the students solve complex problems and discover and apply rules. This supports previous research showing that computational thinking generates the strategic knowledge that is necessary for problem solving (Bers, 2010), and that cognitive tasks related to computational thinking can be addressed through programming (Grover & Pea, 2013). In particular, in the maze escape and school bus tasks in this study, the problem is to grasp the movement path of the robot; this task involves problem decomposition, algorithmic thinking, and abstraction.

Computational Practices

To identify the changes in the students' computational practices that took place during the physical computing classes, we assessed changes in four areas: understanding and structuring the problem, exploring the problem-solving method, experiencing the algorithm, and understanding programming. The maximum score for each area on the computational practice test was 5 points. Figure 5 shows the students' average computational practices scores.

In the area of comprehension of computational practices, the students showed higher average scores in understanding the problem, structuring the area, and programming in the school bus class than in the maze escape class. This is likely because the school bus class is based on material that directly relates to the students' daily lives, so their scores rose in the area of problem understanding. In the area of understanding programming, the students were familiar with programming using commands because they understood the functions of each instruction through practice.

In contrast to the other two computational practice areas, in the areas of problem solving and algorithm experience, the mean score was lower in the school bus class than in the maze escape class. We took this to mean that the students could relate better to the school bus scenario, so it interested them more, but that developing actual bus routes was complicated, and the complex considerations made it difficult for the students to develop algorithms. Regarding the overall computational practice scores by class subject, the students had a higher average score, 9.43, in the school bus class than they did in the maze escape class, 9.22. Table 7 shows the individual students' computational practice scores.

In the problem understanding and programming area, the students' average score was higher in the school bus activity than in the maze escape activity. This may be because the students fully understood a need for a school bus, and the task was related to their everyday lives, so their scores increased in the problem understanding area. In addition, it seems that the functions and programming methods of each area of instruction gradually became more familiar with iterative programming. On the other hand, in the problem solving and algorithm area, the average score of the students in the school bus classes decreased. This seems to be because the situation became more complicated, so it was difficult to address it with an algorithm, despite the fact that the school bus problem is related to the students' everyday lives and the students were interested in the problem.

We conducted correlation analysis to analyze the relationship between students' computational practice scores by subject and the computational practices they displayed in their interviews. The result was .863, which was statistically significant ($p < 0.01$). To analyze the relationship between computational practices and concepts, Pearson's correlation analysis was conducted, which showed correlation

Figure 5

Computational Practice Scores in Physical Computing Lessons

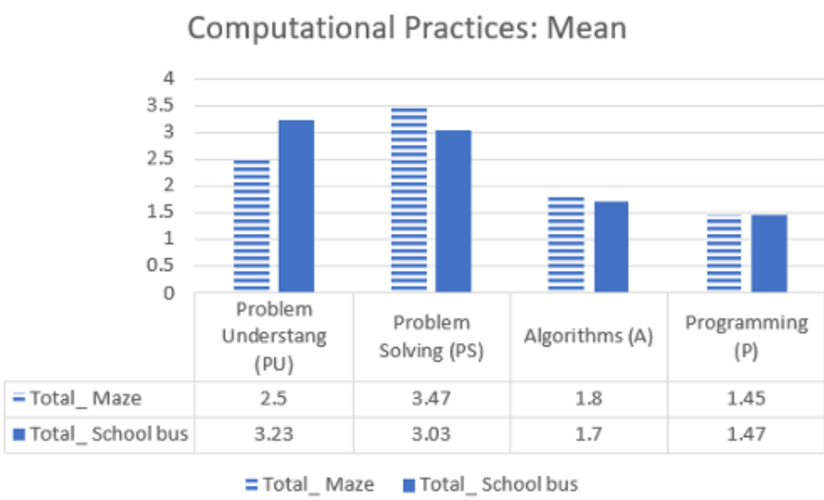


Table 7
Individual Students' Computational Practices Scores

No	Maze Escape					School Bus				
	PU*	PS*	A*	P*	Total	PU*	PS*	A*	P*	Total
1	3.67	4.83	2.33	2	11.83	3.33	2.83	1.67	1.67	9.5
2	2	4	1.67	1	8.67	2.67	3.5	1.67	1.5	9.34
3	2	3	1.67	1.67	8.34	3.67	2.33	1	1	8
4	2	3.67	2.33	2.33	10.33	4	2.5	1.67	1.67	9.84
5	2	4.5	1.67	1	9.17	3	3.67	2.67	1.5	10.84
6	2	4.17	3	2.5	11.17	4	2.5	1.33	1	8.83
7	2.67	2	1	1	6.67	3	2	1.67	1.5	7.5
8	2	2	1.67	1	6.67	2.33	3	1.33	1.5	9.16
9	3.67	3.33	1	1	9	3.33	4.17	1.67	1.67	11.51
10	3	3.17	1.67	1	8.84	4	3.83	2.33	1.67	9.83
Mean	2.50	3.47	1.80	1.45	9.22	3.23	3.03	1.70	1.47	9.43

**PU: Understanding the problem & finding ideas, PS: Exploring to solve the problem, A: Play algorithm, P: Understanding programming.*

coefficients of .758 (*p*< .05) for the pre-test and .877 (*p*< .01) for the post-test. The correlation coefficient for computational practices (*r*= .711, *p*< .05) was statistically significant, indicating that, when conducted after the classes, interpersonal interviewing was effective. The post-test scores for computational concepts and the activities (*r*= .877, *p*< .01) and interviews (*r*= .711, *p*< .05) were all highly correlated. We found that, following the physical computing lessons, the students were able to demonstrate their understanding of computational practices in the class activities and in interviews.

Computational Perspectives

We used anecdotal records to evaluate the student's perspectives on computing accidents (Brennan & Resnick, 2012; Brennan, Balchm & Chung, 2015). We asked students to rate their expression, collaboration, and use of robots and computing abilities with regard to robots and computing on Likert scales of 1 to 5 for each item. Table 8 shows the students' average scores for each item in each step, which were used to examine the changes in their computational perceptions.

Next, Figure 6 shows the students' average scores. In terms of computational perspective, students who attended the physical computing lessons were able to use robots and computing to create something, to be aware of expressions, to collaborate with peers, and to solve problems.

We found it noteworthy that students' expression increased in the actual experiential algorithm execution and reflection stages. In the problem analysis and "find ideas" stages, the expressing, collaborating, and use of robots and computing perspectives of the school bus class (#1) increase more than those of the maze escape class (#2). Our analysis shows that the process of finding problems and discussing ideas with friends leads to a change in computing perspective. In particular, presenting practical problems, such as those having to do with school buses, helps improve computational thinking, which is in line with previous work (Bers, 2010; CSTA, 2012; Wing, 2006).

Pearson's correlation analysis of the relationships between computational concepts and perspectives revealed no statistically significant results (*p*< .05). The correlation coefficient between computational perspectives and computational practice was .469, but this finding was not significant (*p*< .05). We found the relationships between the subdomains to be related to the students' recognition of the expression

Table 8
Average Computational Perspectives Scores

Activity / Step	Analyze Problem & Find Ideas			Formulate Algorithms & Play Algorithms A			Play Algorithms & Reflect Algorithms		
	E-1	C-1	U-1	E-2	C-2	U-2	E-3	C-3	U-3
#1: Maze escape	3.4	3.4	3.3	4	3.8	3.8	4.1	4.1	3.8
#2: School bus	4	4	3.9	3.5	3.5	3.7	3.9	4.1	4
Average score	Maze: Expression (3.83), Collaboration (3.77), Use of robots and computing (3.3)								
	School bus: Expression (3.8), Collaboration (3.87), Use of robots and computing (3.87)								

**E: Expression, C:Collaboration, U: Use of robots and computing* of school buses and computational perspectives (r= .655, p< .05), and their perspectives of connections (r= .735, p< .05). In the school bus class, there was a strong correlation between the expression of computational perspectives and the perspectives of cooperation, given that the correlation coefficient was between .60 and .80.

In summary, the results of this study show that students who participated in physical computing lessons showed an improved understanding of computational concepts. In particular, the number of correct answers increased for the elements of algorithmic thinking, decomposition, and abstraction, including on items with high complexity. The overall average score for computational practices was higher after the school bus lesson, 9.43 points, than after the maze escape lesson, 9.22 points, indicating that the students' overall computational practice comprehension improved. Students' computational practices improved in both classes in terms of their understanding of problems, structures, and programming. The mean scores for problem-solving search area and algorithm experience were lower after the school bus lesson than the maze escape lesson. We interpreted this difference to reflect the fact that the school bus lesson introduced a complex real-life problem that students found difficult to solve, and we concluded that difficulty solving the problem influenced the students' understanding of programming.

In terms of computational perspectives, in the maze escape lesson, as the lesson progressed, scores related to expression, collaboration, and utilization increased. In contrast, in the school bus lesson, we found that the students had difficulty developing algorithms for the complicated bus route problem, and that this difficulty was reflected in their lower algorithm formatting and performance scores.

Conclusion

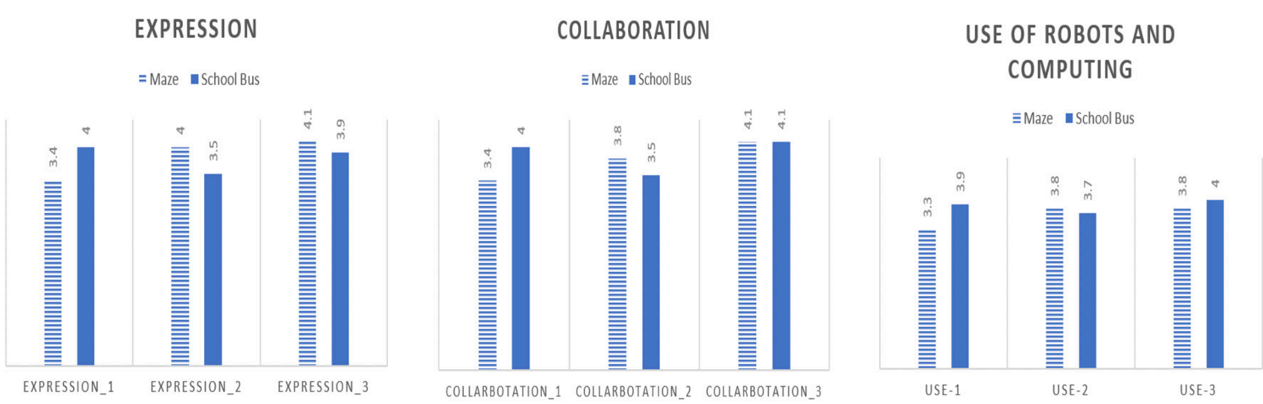
In this study, we developed and applied two sets of physical computing lessons for elementary school students in preparation for their imminent computing education. We measured the students' computational thinking in terms of concepts, practices, and perspectives, not just cognitive aspects, in an effort to overcome previous researchers' focus on only cognitive changes, such as changes in logical thinking (Lee, Cheon, & Kim, 2017), programming understanding (Resnick, 2006), and problem-solving ability (Kabátová & Pekárová, 2010; Son & Son, 2014).

This study has some limitations. For example, it targeted voluntary participants, only male students participated, and it was conducted with a small number of students (10). Thus, it is difficult to generalize the results of this study.

We found that the physical computing lessons supported problem decomposition, abstraction, and algorithmic representations that are covered in students' computational concepts. In particular, the lessons provided an opportunity for students to compare and modify their own mental models and the real models they created for the experiments. The robot programming activities in which students participated during class helped to shape their computational concepts through computational practices. In addition, instructional activities that described how school buses move around schools and neighborhoods helped shape a problem in the students' daily lives. This supports the abstraction, extraction, and expression of key information, thus helping students to distinguish important information from ancillary information, and thereby form computational concepts. This is also reflected in the current emphasis on providing opportunities to

Figure 6

Computational Perspectives: Expression, Collaboration, and Use of Robots and Computing



develop design in software education (Kim & Han, 2012; Jeon & Han, 2016; Brennan, Balchm, & Chung, 2015).

Second, the physical computing lesson facilitated the students' computational thinking by supporting them in rendering their ideas into computing technology, while solving problems with hardware (robots) and software (programming). In addition, the action of formalizing algorithms was educational in terms of activating students' mathematical expressions (symbols, texts, pictures, etc.). In particular, it was possible to utilize physical computing tools to support inquiry learning by enabling variable control and feedback (Reys, Lindquist, Lamdin & Smith, 2015).

Third, the problematic situations encountered by the students in these classes changed their computational perspectives and allowed the students' active interest in the subjects to manifest. Students who took part in the physical computing classes recognized the necessity of cooperation when using robots to solve problems. This resulted in the emergence of active attitudes, such as actively learning the programming language and communicating their learning to other students. In fact, after the study, the students formed clubs and volunteered to conduct research on robots and coding.

This study has many educational implications. The factors that affect computational thinking can be identified by analyzing the patterns of computational concepts and perspectives that are revealed through computational practice. In particular, this study provides concrete implications of the use of physical computing lessons for elementary students, and has educational implications for teachers, researchers, and parents who will be conducting software education in the future.

Based on the results of this study, we suggest the following. First, considering that physical modeling and programming support the formation of computational concepts in physical computing lessons, it is necessary to develop computational practice activities so that students construct knowledge while constructing actual models. Second, when conducting software training, it is important to encourage an understanding of computational concepts, including problem resolution, abstraction, and algorithmic thinking, rather than focusing on automation. Considering that the students' ideas and the ways in which they formed algorithms differed depending on how they perceived the problem, education on the abstraction phase that breaks down the problematic situation and emphasizes an understanding of the core concepts should be made a priority. Third, we conducted this study with only male students, and further study is needed to assess whether there might be gender differences in the results, particularly given that most of the male participants had related experience and a high degree of interest in the class subject.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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School Students' Depictions of Mathematics Teaching and Learning Practices

Vesife Hatisaru*

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*Correspondance Details: Vesife Hatisaru. School of Education, College of Arts, Law and Education, University of Tasmania, Launceston, Tasmania, Australia.
E-mail: Vesife.Hatisaru@utas.edu.au
ORCID: http://orcid.org/0000-0003-2101-1764

Abstract

The current study examined pictorial and written descriptions of mathematics teaching and learning among a cohort of 120 students (aged 11 to 14 years) in three different lower secondary schools in Ankara, Turkey. A classroom environment with students working in groups or pairs and engaging in open-ended questions or tasks was unavailable. The students viewed teaching of mathematics only as instruction and practicing, and that learning occurs when students sit at desks and passively listen to the teacher who stands in front of the class and explains and demonstrates the subject and/or solves routine questions. Implications for policy makers include the need to determine the contributors to students' current perceptions of mathematics teaching and learning experiences. Building positive perceptions relating to mathematics and mathematics learning experiences in students is a prerequisite to enabling students to develop mathematical proficiency.

Keywords:
Draw a Mathematics Classroom Test, Mathematics practices, Mathematical tasks, Representations, School students

Introduction

In a previous study, Hatisaru (e.g., 2019a, 2019b) investigated a large group of 1284 Turkish lower secondary school students' (aged 11 to 14) images of mathematics through examining their Draw a Mathematician Test (DAMT) (Picker & Berry, 2000) depictions and associated descriptions. The students' drawings fell into two distinct groups: depicting a mathematician at work (Hatisaru, in press), or as a mathematics teacher in the classroom (Hatisaru, 2019a). Focusing on the latter group, Hatisaru (2019b) examined the modes of instruction in mathematics classrooms through the students' eyes. This analysis of student drawings and writing revealed that most students depicted, highly teacher-directed mathematics classrooms which relied heavily on the teacher lecturing, explaining, or solving

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exercises. The results, however, were limited to using students' drawings of mathematicians, and revealed a need for further investigations. In the present study, I explore the same age group students' perceptions of mathematics teaching and learning practices by examining their mathematics classroom pictures and associated texts. The research questions asked are, through the students' eyes, in mathematics classrooms: (1) What are the teaching practices of a teacher? (2) What are the learning practices of students? and (3) What materials and tools are used? Mathematical tasks (questions, expressions, equations) in students' pictures and their representational forms (e.g., symbolic, visual, verbal) are also of interest.

Mathematical capability is accepted as one of the key competences necessary for students' success in school and later in life (Smith & Stein, 2011). Although globally students' mathematics performance has showed improvements, many school students still are not reaching the desirable mathematics performance benchmarks (Mullis, Martin, & Loveless, 2016). There has been a stalled or declined mathematics performance in Turkish school students against international benchmarks (e.g., Mullis, Martin, Foy, & Hooper, 2016), and a decline in the participation in tertiary mathematics courses (e.g., Nesin, 2015). This study's findings extend the knowledge of school students' perceptions of mathematics and its teaching and learning previously obtained from questionnaires (e.g., Mullis, Martin, Foy, & Hooper, 2016). The students' pictorial and verbal reflections provide valuable insights which could be useful to understand for future development of mathematics provision in Turkey.

Below, the relevant literature that informed this research is critiqued before the context of the study is discussed. The research instrument is presented followed by the development of its corresponding coding schema and data analysis. Finally, the results of analysis, preliminary conclusions about the teaching and learning practices and resources used in mathematics classrooms seen through the students' eyes, and further research recommendations are presented.

Relevant Literature

The Image of Mathematics

The teacher and student activities depicted, occurring within a mathematics classroom underpins students' perceptions of their mathematics teaching and learning experiences and consequently their images of mathematics as represented in drawings. The image of mathematics construct is defined as the feelings, expectations, experiences and confidence individuals hold about mathematics (Brown, 1992), and is "understood broadly to include all visual and verbal representations, metaphorical images and associations, beliefs, attitudes and feelings related to mathematics and mathematics learning experiences" (Sam & Ernest, 2000, p. 195). Lane, Stynes and O'Donoghue (2014) suggest that the image of mathematics is "a mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers or society" (p. 881). In all current definitions, the image of mathematics is conceptualized as a multifaceted construct composed of several aspects. According to Sam and Ernest (2000), the image of mathematics is composed of, for instance: stated attitudes; feelings; descriptions or metaphors for learning mathematics; views about mathematicians and their work; and descriptions for mathematics learning experiences. To Lane et al. (2014), it involves attitudes, emotions, beliefs, motivation, and self-concepts relating to mathematics and mathematics learning experiences.

Certain components of the image of mathematics involving attitudes towards and beliefs about mathematics have been widely investigated (e.g., Hatisaru & Murphy, 2019; Johansson & Sumpter, 2010; Markovits & Forgasz, 2017). The research in the image of mathematics field still needs more information on the perceptions of students relating to their classroom teaching and learning experiences. Large-scale assessments such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) have identified the perceptions of students in regards various aspects of school and classroom climate, but these studies are limited to responses gleaned from questionnaire items (Vieluf, Kaplan, Klieme, & Bayer, 2012). The statements used in questionnaires are not necessarily understood by school students in the way researchers intended (Bragg, 2007). More detailed information about students' perceptions of mathematics teaching and learning experiences would help to alleviate some of the limitations in the existing literature. It would be also easier to assess the claims about students' performance in mathematics and/or images about mathematics, by reviewing evidence addressing students' perceived classroom experiences.

Teaching and Learning Practices in Mathematics Classrooms

The learning of mathematics has been defined as the achievement of five intertwined strands, which together constitute mathematical proficiency: conceptual understanding; procedural fluency;

strategic competence; adaptive reasoning; and productive disposition (for details, see Kilpatrick, Swafford, & Findell, 2001). In the alignment of the first four of these strands understanding, fluency, problem-solving, and reasoning in mathematics have been seen to represent the basis for mathematical proficiency (Australian Curriculum Assessment and Reporting Authority [ACARA], 2018). These proficiency strands have been variously described as the standards or the practices that students need to engage with during mathematics learning to become proficient in mathematics (ACARA, 2018; National Council of Teachers of Mathematics [NCTM], 2014). In the USA, these practices are called Common Core State Standards for Mathematics (CCSSM) and involve: making sense of problems and persevering in solving them; reaching viable arguments and critiquing the arguments of others; modelling with mathematics; and using appropriate tools strategically (National Governors Association Centre for Best Practices and Council of Chief State School Officers [NGA Centre and CCSSO], 2010).

The teaching that fosters mathematical proficiency can take a variety of forms. Kilpatrick et al. (2001) suggest that the effectiveness of teaching depend on, among other things, selecting cognitively demanding tasks and engaging students with learning tasks by using manipulatives representing mathematical ideas. Swan (2005) presents a set of principles that should underline all effective teaching practices. According to Swan (2005), teachers should use rich collaborative tasks because such tasks can promote discussion and communication, and when combined with the use of technology in appropriate ways, engage and motivate students. Anthony and Walshaw (2009) describe worthwhile mathematical tasks, making connections among mathematical ideas, mathematical communication, and the use of tools and representations as effective mathematics teaching practices. Bobis, Anderson, Martin, and Way (2011) present four strategies for teaching practices: variety in teaching approaches; real and relevant tasks; open-ended questions; and using errors as a focus for learning. The NCTM (2014) has developed a further phase of the education standards initiative, Principals to Actions: Ensuring Mathematical Success for All, and represents a set of research-informed mathematics teaching practices. A few are: implementing tasks that promote problem solving; using and connecting mathematical representations; and building procedural fluency from conceptual understanding.

The specific teaching practices that appear to be most common include, utilising rich open-ended tasks, selecting problems for which there are multiple methods of solution, using appropriate tools to explore those problems and deepen understanding of concepts, and giving students more active roles in the learning process.

Using Drawings to Explore Students' Perceptions of Mathematics Practices

Science education researchers (e.g., Chambers, 1983) have contributed much to the conceptualization and assessment of the drawing method, followed by mathematics education researchers. The historical beginnings of the drawing method in science education have been provided in Thomas, Pedersen and Finson (2001) and Finson (2002). Hatisaru (2019a) has reported the beginnings of adaptation of the drawing method to mathematics education. Here, a synthesis of research into utilising drawings to investigate students' mathematics classroom perceptions, with a focus of the method's validity, is presented.

The use of drawings as a measure of students' conceptions of teaching and learning has been found to be valid and useful (e.g., Gulek, 1999; Harris, Harnett, & Brown, 2009; Hatisaru, 2019a; Laine, Ahtee, & Näveri, 2020; Losh, Wilke, & Pop, 2008), and a cost-effective alternative to interviews and classroom observations (Haney, Russel, & Bebell, 2004). Studies designed to validate whether students' depictions are representative of their actual classroom experiences, through incorporating teacher interviews and classroom observations (Remesal, 2009) or classroom video recordings (Laine et al., 2020), have found a close link between the student drawings and their actual classroom practices. Remesal (2009) reports that, "this awareness [of perceptions of classroom assessment practices] develops even though the teachers themselves might not believe 8-year olds are capable of such insights" (p. 47).

The drawing method offers more opportunities for students to express their core opinions about mathematics, and mathematics teaching and learning, than questionnaires (Stiles, Adkisson, Sebben, & Tamashiro, 2008). Through this method, students are given control of the data collection process and can draw freely about their experiences of mathematics (Kearney & Hyle, 2004). Student drawings therefore contain rich information on their thoughts about mathematics and its teaching and learning (Pehkonen, Ahtee, & Laine, 2016). The drawing method has been widely used to elicit data from students regarding their image of science and mathematics in many countries and on different continents including in

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Europe, the Middle East, Asia, and the USA. In Hatisaru (2019a), an extensive review on past research using drawings to access various components of the images of mathematics held by school students is reported. In the following section, perceived mathematics teaching and learning practices found in student drawings are presented.

Previous Research Findings

Picker and Berry (2000) investigated the perceptions of mathematicians held by school students (12 to 13 years old) in the USA, the UK, Finland, Sweden, and Romania by using the DAMT and compared their images. The students' images were found to be common with small cultural differences. The students quite often pictured mathematicians as a mathematics teacher in the classroom and found getting the correct answer was the most important thing in mathematics lessons. The students' pictures frequently involved questions such as: "What's the answer? What is the result? What's going on here?" (p. 84). Most participant students' DAMT drawings were similarly shown in the classroom in another study in the USA (Rock & Shaw, 2000). The students (kindergarten – grade 8) named tools that they were familiar with from their own classrooms (e.g., paper, pencils, whiteboards) as the tools of mathematicians. The second and third grade students mentioned calculators, rulers, geometric shapes, while fourth grade and middle school students expanded their responses to include computers, calculators, and protractors.

Johansson and Sumpter (2010) investigated grade 2 and 5 students' conceptions about mathematics and mathematics education revealed in their drawings in Sweden. Mostly positive attitudes about mathematics were found. The younger students viewed learning of mathematics as an individual activity, while the elder students narrowed down it to calculating. Pehkonen, Ahtee, Tikkanen, and Laine (2011) used drawings in Finland to reveal students' (8-9 years old) conceptions of mathematics and its teaching. Of 153 student drawings, every second drawing included indications of attitudes about mathematics such as: mathematics is nice; easy; dull; or difficult. A total of 102 drawings indicated a classroom environment where students in the picture were in action such as thinking, speaking, or discussing. Laine, Näveri, Ahtee, Hannula and Pehkonen (2013) further analyzed these drawings to study the kind of emotional atmosphere in a mathematics lesson that could be seen in the students' depictions. A positive emotional atmosphere was found in the most pictures. Pehkonen et al. (2016) examined the same student drawings to explore the types of work experienced during a mathematics lesson through the eyes of students. The types of work most frequently depicted were independent work (students work individually for solving problems from textbooks or given by the teacher) and work with the teacher in charge (the teacher teaches the whole class, or all students work on the same task). Group work (students working with classmates on a task) was less common in students' pictures. Remesal (2009) used drawings to explore how primary school students (7 to 8 years old) perceived assessment practices in the classroom, and how students' conceptions might be shaped by their actual classroom experiences in Spain. Two practicing teachers and their twelve students participated in the research. Interviews with the teachers and students, classroom observations, and students' drawings of mathematics classrooms were collected. The students perceived assessment practices as: "'someone is to ask and someone is to respond,' 'someone is to show the work and someone is to mark the work,' 'grades are given and the parents are informed'" (p. 47).

Ucar, Piskin, Akkas, and Tasci (2010) used drawings to investigate elementary school students' (grades 6 to 8) beliefs about mathematics and mathematicians in Turkey. They found that the students associated mathematics predominantly with numbers, formulas, or computations, and believed that mathematicians could be (purely) needed for their computational skills. Being good at mathematics, meant to the students, finding a correct answer to questions, even if not necessarily understanding the questions. Hatisaru (2019a) found that many Turkish students pictured their former or current mathematics teacher teaching in the classroom as a mathematician at work. The students viewed that the main activity of teachers was solving mathematics practice questions. Further analysis (Hatisaru, 2019b) showed, in the students' pictures, the most common mode of instruction was direct teaching. No evidence of a student-centered mode of instruction existed. A whiteboard and/or books were the most frequent teaching resources in classroom portrayals, while physical manipulatives and technological tools were notably absent.

Although an extensive drawing-based research has been carried out concerning students' perceptions of mathematics classroom practices, little attention has been paid to the voice of students in Turkey. The existing DAMT research findings are limited to using students' drawings of mathematicians. Student drawings have not yet been utilized to my knowledge to investigate how students perceive the types of mathematical tasks and forms of representations used in the classroom. This study extends the current literature by providing: (1) an analysis of data from Turkish school students regarding their perceptions of teaching and learning experiences in mathematics classrooms; and (2) additional evidence with respect to students' perceptions of two key aspects of classroom practices: mathematical tasks and their representations.

The Study

Context

In Turkey, students attend lower secondary education for four years (grades 5 to 8, aged 10 to 15). Mathematics is taught as a mandatory and major subject during all level of schooling and is part of national end of lower and upper secondary education exams which students sit at the completion of the lower secondary and high school, respectively. Mathematical questions make up 22% of the questions for high school entrance exam and 33% of the questions for the university entrance exam (European Schoolnet, 2018). Teaching in schools is regulated by the national curriculum. The learning and teaching practices suggested by the curriculum are similar to those suggested by international research studies and curricula. The goals of the lower secondary school mathematics curriculum (Ministry of National Education [MoNE], 2018) for students include: developing and using mathematical literacy skills effectively; understanding mathematical concepts and using them in daily life; expressing their reasoning in problem solving processes; and representing the concepts in different representational forms (p. 9). The curriculum encourages teachers to embrace teaching strategies which are inclusive of students' individual differences in mathematics learning and highlights the need for students to be active in their learning. A few suggested mathematics teaching practices include: the use of manipulatives in introducing new concepts and assessments when available (e.g., number cards, base ten block, fraction tiles or real-life models); encouragement of students to express their thinking orally and communicate their thinking both individually and in groups; and making connections across mathematics topics and other disciplines when relevant (p. 13-14, translation by the author).

Data Source and Generation

Data was generated through the Draw a Mathematics Classroom Test (Hatisaru, 2020a), adapted from the DAMT (Picker & Berry, 2000) and Draw a Science Teacher Test (DASTT) (Thomas et al., 2001), and Gulek's (1999) work on using drawings to examine the educational ecology of classrooms. The Draw a Mathematics Classroom Test focuses on the pedagogical and curricular elements of the classroom (Evans, Harvey, Buckley, & Yan, 2009). The test combines drawings with written responses. It provides a rectangular area in which students are asked to draw a picture. A prompt of: "Think about teachers of mathematics and the kinds of things you do in mathematics classrooms. Draw a picture of your teacher teaching and yourself learning" is given. At the bottom of the sheet, the following prompts are given to get students to describe their drawing: "Look back at the drawing and explain your drawing so that anyone looking at it could understand what your drawing means. What is the teacher doing? What are the students doing? What materials and tools are they using?" The use of drawing tasks with an accompanying text adds rigor to the instrument as the information provided in the writing reduces the subjectivity effect in coding the drawings (Murphy, Delli, & Edwards, 2004).

The data was collected at the beginning of 2018–2019 academic year. A sample of 400 students, in grades 6 to 8 (aged 11 to 14 years), enrolled in three different lower secondary schools (two public, one private) located in Ankara, participated in the data collection process under the auspices of school principals. The schools were co-educational metropolitan schools with a relatively middle socioeconomic population based on family income. The instrument was implemented in Turkish, by counseling teachers at a time set aside by the school for school counseling, as that was convenient for the schools and minimized disruption. Students took the task individually in about thirty minutes and were not given extra drawing materials. In each school, there were four to eight mathematics teachers, most could be called mid-career. In data analysis, a priori thematic saturation, referring to the degree to which pre-determined codes or categories being sufficiently replete with instances of data (Saunders et al., 2017) was employed. Of the 400 responses, 120 were analyzed (for more details, see Coding). Male (n= 61) and female (n= 54) students were almost equally represented across this sample, while the number of grade 7 (n= 40) and grade 8 (n= 66) students were greater than the number of grade 6 (n= 12) students. Participants were designated by codes (e.g., S1, S2, S3 and so on).

Data Analysis

To analyze the drawings and associated written descriptions a deductive content analysis was used (Elo & Kyngäs, 2007). Specifically, this required a process of becoming familiar with and making sense of the data. Firstly, I inspected students' pictures and read associated descriptions several times. As learning activities and tasks that are utilized in classrooms is part of teaching and learning practices, I decided to analyze also the latent (silent) content of students' responses. This content involved depictions of written mathematical work (formulas, questions, equations, or expressions) on the whiteboard, and their representational forms (e.g., symbolic, visual). With assistance of a graduate research assistant, the data was transcribed and documented using excel spreadsheets. A coding schema was used for data analysis (see below).

Operationalization of the coding schema

To decide the coding categories, I drew upon the DASTT Checklist (DASTT-C) (Thomas et al., 2001). The DASTT-C consisted of three sections: Teacher (the teacher's activity such as demonstrating or lecturing and the teacher's position such as head of the classroom), Students (students' activity such as passive information receiver, responding to the teacher, and the position of the students such as seated in rows), and Environment (elements typically found inside classrooms such as desks in rows, symbols of teaching like whiteboards and materials). Drawing on the DASTT-C and focusing on the elements that emerged in the students' drawings particular to this study, I identified three main categories of classroom practices in the depicted pictures and drafted a coding schema. They are: (1) Teaching practices which identified the depicted teacher's roles and activities, (2) Learning practices which involved the depicted students' roles and activities, and (3) Teaching resources which assessed the teaching materials and tools utilized in the classroom, involving the characteristics of mathematical tasks and their representational forms (see Table 1).

The meaning of categories was informed by the relevant literature. Variety in teaching methods is defined as blending teacher-directed methods (e.g., explanation, demonstration, questioning, giving examples) with student-centered approaches (e.g., group work, problem-solving, student presentations, open-ended tasks) (Bobis et al., 2011). The teacher activities regarding the former methods involve, telling students which questions to do or to work through practice exercises, while the latter ones involve students learning through discussing their ideas, or working in pairs or small groups (Swan, 2006). The teaching methods in student drawings include scenarios where student desks are in rows, the teacher is depicted at the blackboard/ teacher's desk, and teacher talk, if any, is lecturing or disciplining. These indicate a teacher-directed mode of instruction. Scenarios indicate a student-centered mode of instruction in pictures where student desks are clustered, students are working in groups, teacher talk, if any, invites discussion, students are engaged in an activity, and the teacher is with or nearby students (Gulek, 1999).

Variety in teaching resources is defined by implementing various types of tasks and utilizing different materials and tools in exploring mathematical concepts and processes. Such materials might involve digital tools, concrete manipulatives, worksheets, models, calculators, and videos (Bobis et al., 2011). The types of mathematical tasks can be categorized into four: tasks requiring practicing procedures (Procedural) (e.g., Can you solve 7x+4=5x+8?); tasks requiring the use of models or representations (Representational) (e.g., Giving students cards depicting the same mathematical idea (polyhedron) in different representations (verbal, visual, pictorial) and asking them to match the cards to enable them to draw links between representations of the same concept); tasks drawing from realistic contexts (Contextual) (e.g., If one pre-paid card for downloading music offers 16 songs for $24, and another offers 12 songs for $20, which is the better buy?); and tasks enabling the use of different solution strategies (Open-ended) (e.g., On squared paper, draw as many different parallelograms as you can with an area of 12 square units) (Sullivan, 2011).

Mathematical tasks and ideas in teaching can be represented in five distinct types of representation systems: Visual; Symbolic; Verbal; Contextual; and Physical. (Lesh, Post, & Behr, 1987). Visual representations refer to anything made by hand or generated by computer that represent concrete objects such as a graph, chart, tallies, or table. Symbolic representations include numbers, formulae, geometric concepts, and numerical or algebraic expressions. Verbal representations incorporate the specialized language required of mathematical domains (e.g., fractions, probability). Contextual representations refer to situations happening in the real world (e.g., using money in shopping), while physical representations include concrete objects or manipulatives (e.g., base ten blocks; protractors; geoboards) that are designed to give students opportunities to learn mathematical concepts by manipulating them (Johnson, 2015).

Drawing upon these theoretical framings provided by the research studies mentioned above, a draft coding schema was developed. The research assistant and I used the draft coding schema independently and coded thirty randomly selected drawings. We then checked how well the coding schema categories covered the data and discrepancies in each of our coding trials. Only minor discrepancies came up. Table 1 presents the coding schema categories and their descriptions, after a few adjustments. Namely, a sub-category (inviting open-ended discussions), in the draft, was removed from the coding schema as there was no reference to a teacher activity inviting students to an open-ended discussion. The Sullivan's (2011) categorization of mathematics tasks and Lesh et al.'s (1987) taxonomy of representation systems

Table 1
Categories of the Coding Schema and their Descriptions

Main category	Generic category	Sub-category	Description
Teaching practices	Teacher activity	Disciplining	Disciplining the class, asking students to be quiet
		Instructing	Instructing, demonstrating, explaining about mathematics
		Solving/asking PQs	Solving or asking students to solve practice questions
	Teacher position	Centrally located	Head of class, standing in front of the class, pointing to or writing on the whiteboard, nearby or sitting at the teacher's desk
		With/nearby students	With or nearby students, sitting in with students or pairs, bending down
Learning practices	Student activity	Watching/listening	Watching or listening to the teacher teaching
		Responding/solving practice questions	Responding to the teacher asking answers for practice questions or solving practice questions
		Working in groups/ pairs	Working in groups or pairs, engaging in an activity collectively
	Student position	At the desk/white-board (alone)	Only one student depicted, sitting at a desk or at the whiteboard, or suggested by classroom furniture
		At the desk and seated in rows	More than one student, sitting in rows or suggested by classroom furniture
		Seated in semi-circle	More than one student, sitting in clusters or suggested by classroom furniture
Teaching resources	Materials and tool	Standard	E.g., whiteboard, notebooks, textbooks, pencil
		Alternative	E.g., digital tools, concrete manipulatives, models, calculators, videos
	Mathematical tasks	Procedural	Tasks that give students opportunities to practice procedures in a mathematics content domain
	Representations	Symbolic	Numbers, numerical/algebraic expressions/equations
		Visual	Depictions such as graphs, tables, diagrams
		Verbal	Specialized language of mathematics regarding mathematics content domains

were used to analyze the nature of mathematical tasks and their representational forms. The coding schema did not involve Representational, Contextual and Open-ended tasks, and Contextual and Physical representations as there was no reference to any of these tasks and representations. The available Mathematical tasks in pictures corresponded to Procedural type of tasks, while representational forms of tasks matched to Symbolic, and, in a few cases, to Visual or Verbal form. The Procedural sub-category composed of seven groups (see Table 3 in the Results section).

Coding

The research assistant and I used the coding schema and coded thirty random drawings to calculate the degree of agreement between us (McHugh, 2012), achieving 93.75% agreement. As a result of this high score, we shared the coding of the remaining drawings equally between us. Throughout the coding, we discussed issues, if any, that required further attention for consensus. The written narrative descriptions contributed to gaining a deeper understanding of what students had drawn and confirmed our interpretations of input in drawings. Each sub-category was coded in a dichotomous fashion, whether each of these elements seemed to be represented in drawings and/or written descriptions or not: 1- There is indication; or 0- No indication. When the drawing or writing was not clear enough to decide, we coded them as: NC- Not clear. Some responses were coded in more than one category. This response: "Smart board, notebook, pencil" (S108, grade 8, boy), for instance, was coded across Standard and Alternative materials and tools sub-categories. Three drawings were excluded as they did not include enough information.

As mentioned earlier, a priori thematic saturation was employed to gauge the degree to which pre-determined codes or categories were sufficiently represented in the data (Saunders et al., 2017). Specifically, while coding we found that there was little variation in student responses. In many of the pictures and texts the same categories were present or not. After the eightieth drawing, we considered that the categories were adequately represented in the data. We continued to coding data for forty more drawings to ensure and confirm that there was no variety in the remaining drawings. As we began to see the same student depictions and descriptions repeatedly, we became confident that the categories were saturated and terminated the coding of the remaining drawings.

Two student responses are presented in Figure 1 to illustrate the coding. In S43's response: Instructing; Centrally located; Watching/listening; Sitting in rows; Standard; Procedural; and Symbolic, and in S58's response: Solving/asking practice questions; Centrally located; Responding/solving practice questions; Sitting in rows; and Standard, sub-categories were assigned with: 1- There is indication as they include references to them. In S58's response there is no explicit reference to mathematical tasks or their representational forms, therefore, these sub-categories were assigned with: 0- No indication. The mathematical tasks ($5^3.4^3$=? and $8^3:8^2$=?) in S43's picture were grouped into Procedural (practice questions), as they seem to be practice exercises requiring use of procedural knowledge in a mathematical content (exponents).

Results

Table 2 shows the frequency of responses corresponding to coding schema categories for the whole sample. In this section the findings for teaching and learning practices, and teaching resources, found in the students' responses are described.

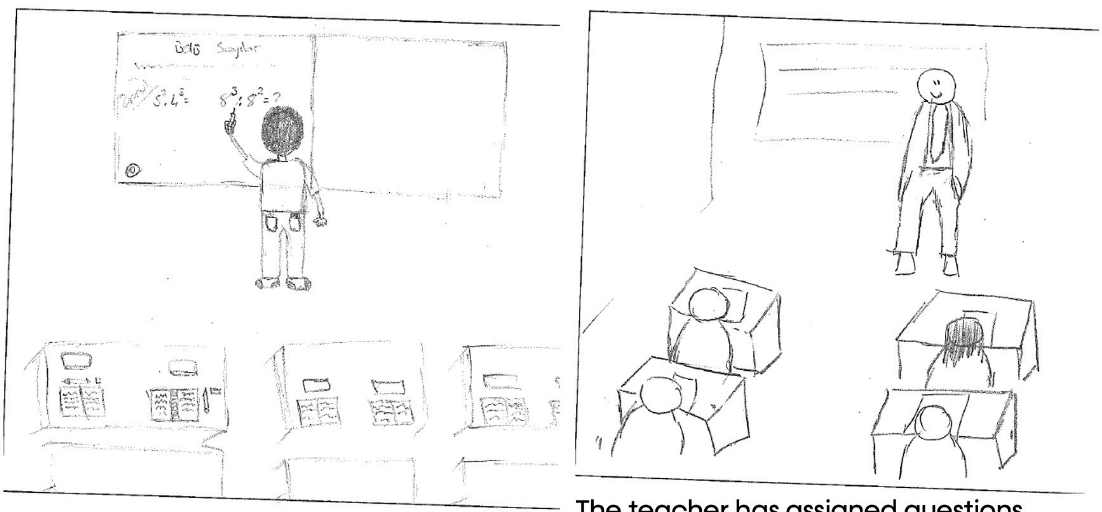
Teaching and Learning Practices

A great majority of responses included clear indications that the depicted teacher was transmitting mathematical facts and procedures to students. Figures 1 and 2 provide typical examples of student responses. In almost all responses (97.4%), the teacher was portrayed as the head of class. They were mostly depicted in front of the class, pointing to (Figure 2, S19) or writing on the whiteboard (Figure 1, S43). In approximately 83% of the responses, teachers were pictured and described as instructing, demonstrating or explaining about mathematics, while in about 36% of responses as solving mathematics practice exercises or assigning students for finding answers to them (Figure 1, S58). The students' texts abounded with statements such as: "The teacher is explaining exponential numbers to students" (S8, grade 8, boy); "Our teacher is teaching to us and he asks to the ones who don't understand to stand up and explains to them. We use pencil, eraser, ruler, book, notebook. What we do is having a class. What the teachers does is lecturing" (S85, grade 6, boy). None of the diagrams show the teacher standing or sitting with or near students. Neither was there a reference to a teacher activity inviting students to an open-ended discussion or having a collaborative activity with students.

Little variation was found in students' responses regarding learning experiences. In most responses (about 83%) students were drawn as relatively passive: watching or listening the teacher who was delivering a mathematical content. In 26.5% of drawings, students were portrayed as being made by the

Figure 1

S43 and S58's Drawings and Texts of the Mathematics Classroom



The mathematics teacher instructing the subject. Students are listening and taking notes. (S43, grade 8, girl)

The teacher has assigned questions, students are solving the questions. (S58, grade 8, girl)

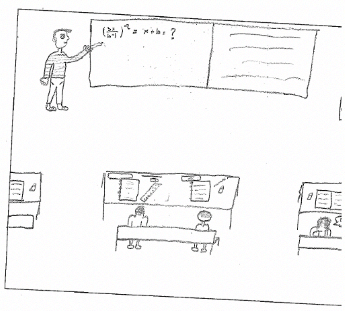
Table 2
Students' Responses Corresponded to the Coding Schema Categories (N=117)

Main category	Generic category	Sub-category	Level of inclusion: '1'
Teaching practices	Teacher activity	Disciplining	5(4.3%)
		Instructing	97(82.9%)
		Solving/asking PQs	42(35.9%)
	Teacher position	Centrally located	114(97.4%)
		With/nearby students	-
Learning practices	Student activity	Watching/listening	97(82.9%)
		Responding/solving PQs	31(26.5%)
		Working in groups/pairs	-
	Student position	At the desk/board (alone)	64(54.7%)
		At the desk, seated in rows	43(36.8%)
		Seated in semi-circle	8(6.8%)
Teaching resources	Materials and tools	Standard	113(96.6%)
		Alternative	8(6.8%)
	Mathematical tasks	Procedural	94(80.3%)
	Representations	Symbolic	85(72.6%)
		Visual	3(2.6%)
		Verbal	2(1.7%)

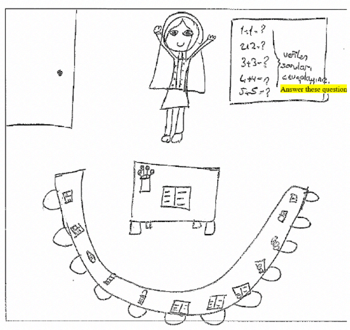
teacher to find answers for practice questions (Figure 2, S63) or practicing mathematics exercises (Figure 1, S58). Much of the student text abundantly involve descriptions of learning experiences such as: "The teacher is lecturing, students are listening to him at their seats" (S82, grade 6, boy); "The teacher is writing questions and students are solving" (S101, grade 7, boy); or "The teacher lectures and asks questions, the student answers. Whiteboard and desks are used" (S5, grade 8, boy). One of the students wrote: "An ordinary mathematics class (boring)" (S13, grade 8, boy).

In general, the physical setup of student desks indicated the traditional lecture form consisting of rows of seating. In many depictions, students face the

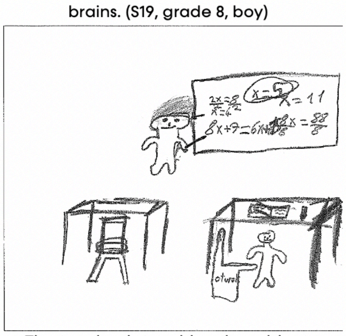
Figure 2
Examples of Student Drawings and Texts of the Mathematics Classroom



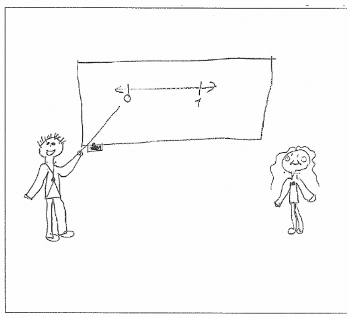
The teacher is lecturing. Some of the students are listening, some are not. We use notebook, pencil, eraser and our brains. (S19, grade 8, boy)



In the picture, the teacher is teaching. Children are listening. (S63, grade 7, girl)



The teacher is teaching the subject, students are listening. They are using textbook and pencil. (S64, grade 8, boy)



The mathematics teacher is explaining something, the girl does not understand, and the teacher is demonstrating her. (S75, grade 6, girl)

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teacher with their backs to one another (Figure 1, S58) indicating no student-student interaction. Also, none of the student text included descriptions indicating any interactions among students, or between students and the teacher while working on an activity collectively. In about 55% of drawings there is one student sitting at the desk. In several cases students were depicted at the whiteboard (Figure 2, S75). In approximately 37% of other drawings, more than one student is shown, and all are sitting in rows (Figure 2, S19). Sometimes this configuration is suggested by the drawing of classroom furniture (Figure 1, S43). In about 7% of pictures (n= 8), the semi-circle setup where students face each other while the teacher is lecturing is depicted, but even in these drawings no descriptions accompanying these depictions indicate student-student interaction (Figure 2, S63).

Teaching Resources

There was little indication of alternative teaching materials such as technological or digital tools, concrete manipulatives, or videos in student drawings. While in a few responses a computer (n= 1) or smartboard (n= 7) was mentioned, in the majority of responses (97%), standard classroom materials such as a whiteboard, notebooks, textbooks, pencils (in a few cases an eraser and ruler) were depicted or mentioned as materials used by the teacher and students. In a few responses, the students described their picture as: "Notebook and pencil are enough" (S27, grade 8, boy); or "Materials are not required much" (S23, grade 8, boy), indicating that students did not view manipulatives and technological or digital tools as instruments used in mathematics teaching and learning.

Among the whole group, while 23 responses (19.7%) involved no mathematical work, 94 responses (80.3%) included depictions or text of the mathematical work engaged in by the teacher and students. The mathematical tasks in many responses (about 31.6%) consisted of performing standard algorithms with fractions, square roots, exponentials or solving algebraic expressions, or calculations of square roots or exponents (see Table 3). The pathway to a solution in these tasks is implied as they are routine exercises. The tasks do not seem to require the use of different strategies such as drawing a diagram, making a table, or guessing and testing, nor do they consist of additional contexts or meanings.

In the remaining responses, the mathematical work involved either the four basic mathematical operations (12.8%) or a numerical/algebraic equation/expression (about 30%). The final group (6%) indicated that the mathematical work was practicing questions. In this group, students usually scribbled on the whiteboard and described the mathematical activity as performing exercises such as: "After teaching the subject at the beginning and solving a few examples, our teacher is giving us questions and [we are] answering the questions" (S26, grade 8, boy). The given context in these responses is such that the focus of the questions could be determined to be procedural fluency, with students shown to be using procedures and algorithms to reproduce previously learned facts. To illustrate, in describing his picture, S115

Table 3
The Nature of Mathematical Tasks Depicted in Drawings

Nature of the task	Frequency	Example
Practice questions	37(31.6%)	√100=? (S2, grade 8, girl) What is the square of 7/9 ? (S71, grade 7, boy) √(4+x)=? (S96, grade 7, girl) 2^x=3,8^x=? (S14, grade 8, boy) 2/3+1/3=? $2,\bar{5}$=? (S91, grade 7, girl)
Basic operations	15(12.8%)	2+2=4 (S3, grade 8, girl) 2x2=4 (S77, grade 6, boy)
Numerical equations	14(12%)	2.2.2=2^3=8 (S24, grade 8, boy) 5^{-3}=1/125 6^{-3}=1/243 (S57, grade 8, boy)
Algebraic expressions	9(7.7%)	a^b; a^{-b} (S31, grade 8, girl) 2x+7 (S94, grade 7, girl)
Algebraic equations	6(5.1%)	2x+3x=5x (S112, grade 8, girl) x+2=0 (S73, grade 7, boy)
Numerical expressions	6(5.1%)	4^{-5}; 2.2; 2^{-3} (S50, grade 8, boy) $1,8\overline{111}$... 1,9 (S92, grade 7, girl)
Scribbles (indicating practice questions)	7(6%)	[Scribbles on the whiteboard] The teacher comes, writes a question on the board, then asks a student to solve the question. (S49, grade 8, girl)
No indication	23(19.7%)	---

(grade 8, boy) stated: "The teacher is solving questions at the smart board. Always. All the time, always, until death". He depicted: "...+...=... ...-...=... ...+...=... " and wrote: "[The teacher:] Let's perform this question". His visual and the written text describe a classroom context in which routine exercises appeared to be the only activity performed.

The form of representations in the depicted mathematical work is predominantly symbolic (72.6%), mostly involving equations and expressions (Table 2). The mathematical work in three responses represents static pictures (visual): a number line (Figure 2, S75), a cube, and a set diagram and graph. In two drawings, verbal representations are evident. In one response the probability of certain events is mentioned: "Then 1 means certainty doesn't it? [the event will happen; its probability is 1]" (S117, grade 8, girl), and in another, the concept of square root is represented: "A quadratic number is the square of a number" (S56, grade 8, boy). The representation of tasks was not clear in the remaining responses as they were scribbles (6%), or there was no reference to a mathematical task (19.7%).

Discussion

The findings demonstrated that participant students perceived their mathematics classrooms as follows: mathematics classrooms are directed by the teacher wherein the teacher is at the center of instruction and learning; the teacher explains and demonstrates the subject and/or solves routine questions. Students sit at desks and listen to the teacher who stands in front of the class and lectures. The class mostly practices procedures, closed mathematics questions with one answer; working on open-ended questions or tasks is not that usual. The interaction between the teacher and students in the classroom is limited to asking and answering routine mathematics questions, while almost no content-related interactions among students occur. A whiteboard and notebooks/textbooks are the main teaching and learning materials. Mathematics is commonly represented through symbolic representations (numbers, equations, expressions).

The study findings support earlier results, which showed that Turkish lower secondary, or elementary (Turgut & Turgut, 2020), school students perceive their mathematics classrooms as highly teacher-directed where students passively listen to the teacher who stands in front of the class and transmits facts, mathematical operations and procedures to students (Hatisaru, 2019b). The findings are also consistent with research internationally which have reported that many students associate mathematics predominantly with routine procedures or operations (Hatisaru, in press; Picker & Berry, 2000; Rock & Shaw, 2000; Ucar et al., 2010) and view learning of mathematics as an individual activity (Johansson & Sumpter, 2010). Students generally perceive the types of work experienced in mathematics lessons as work that the student studies individually, solving problems from textbooks or given by the teacher, while the teacher teaches the whole class (Pehkonen et al., 2016). What is surprising in this study, however, is that there is no variation in student responses in terms of teaching and learning practices, and in teaching resources used in the classroom. Almost all of the 117 students depicted and described the same classroom experiences. In contrast to Rock and Shaw (2000), students in grades 6, 7 and 8 mentioned the same paper-based materials as tools of the teaching and learning mathematics rather than some alternative resources, and to Pehkonen et al. (2011), student pictures contained hardly any active learning practices such as thinking, speaking, or discussing. Although this was not an aspect of the data analysis, as opposed to findings in Laine et al. (2013), the kind of feelings in students' responses were relatively neutral ("They [students] are sitting. Listening to the teacher. The teacher is lecturing. It is important to use pencil and eraser" S57, grade 7, boy), or in several instances rather negative (e.g., S13).

These findings are worrying for a few reasons. First, teaching practices that are characterized as traditional (direct teaching where students are being asked to memorise and apply facts and procedures) can negatively impact students' attitudes towards mathematics, resulting in students not remaining engaged and being successful in mathematics (Boaler, 2015; Swan, 2006; Smith & Stein, 2011). This type of instruction may increase students' factual knowledge and their competency in solving routine problems, but they have no significant effect on students' reasoning skills (Bietenbeck, 2014; Swan, 2006; Vincent-Lancrin et al., 2019). If the descriptions of students in this study are typical, it is highly probable that Turkish students have many opportunities to practice procedures to become fluent in them. Rich discussions based on more open-ended problem-solving tasks, nevertheless, appear to be absent in the classroom teaching that many students experience.

Second, there is consistent evidence that students' perceptions of classroom learning environments are associated with their learning outcomes (Fraser, 2014) involving mathematics performance (Wong, Marton, Wong, & Lam, 2002), and interest in (Latterell & Wilson, 2012) and attitudes about (Hatisaru & Murphy, 2019; Picker & Berry, 2000) mathematics. The long-term learning outcomes of a student who described her mathematics classroom as: "The teacher is lecturing but in a boring way. Students listen to him and take notes. They really don't want to be taught mathematics. All are sad. The class is boring. All the teacher is doing is lecturing and giving examples. Very boring!" (S18, grade 8, girl); or who thought: "I don't understand anything in mathematics. She [the teacher] always gives us problems to solve without explaining properly. Most of the students don't understand. Pencil, notebook [are used]" (S9, grade 8, girl), would negatively be impacted by their reported classroom experiences.

The classroom learning environment created by teachers plays a significant role in shaping students' perceptions of school subjects and how new knowledge is created regarding those subjects (Picker & Berry, 2000; Tsai, 2000). A possible explanation for participant students' perceptions might be that students regularly experience direct teaching practices in their mathematics lessons, like many other students across the world (Nistor, Gras-Velazquez, Billon, & Mihai, 2018; Vincent-Lancrin et al., 2019). The instructional practices, however, cannot be thought of in isolation to contextual factors (Anthony & Walshaw, 2009; Kilpatrick et al., 2001). The preponderance of direct teaching practices may be specific to Turkey where students are placed in high schools and universities based on their nationwide multiple-choice standardized test scores. As their test scores determine which high school or university a student goes, students give much importance to mathematics (Hatisaru, 2020b) and practising test questions is important, even while they may not necessarily understand the questions (Ucar et al., 2010). Mathematics teachers utilize more direct instructional practices in the classroom in response to the students' needs (Altinyelken & Sozeri, 2017; Nistor et al., 2018; Vincent-Lancrin et al., 2019) and use chiefly paper-based materials in their teaching in line with teacher-led instructions (Nistor et al., 2018). This trend unfortunately shows little variation with higher levels of teaching experience; that is, more years in teaching mathematics rarely means more variety in teaching methods (Nistor et al., 2018). There are concerns among mathematics educators that many students are successful in solving test questions, but they are not necessarily building mathematical understanding (Tunc-Pekkan, 2019).

The student response pattern of, not viewing technological tools and concrete manipulatives as tools found and used in mathematics classrooms could be their classroom realities. The current mathematics curriculum suggests teachers use manipulatives (e.g., number cards, base ten block, fraction tiles, or real-life models) and technology in introducing new concepts and assessments where applicable (MoNE, 2018). It is yet probable that the use of physical manipulatives and technological or digital tools were not regular classroom experiences of participant students (Nistor et al., 2018), perhaps because such teaching resources were unavailable to the teachers in participant schools (Erbilgin, 2017), or possibly that the teachers in participant schools had lack of knowledge or confidence in, or unfavorable beliefs about, incorporating varied technologies in their classroom teaching (Altinyelken & Sozeri, 2017). In the absence of observational or interview data, the study is unable to confirm these possible explanations for relevant response patterns. However, student perceptions showed that engaging in experiential learning practices and developing technological and digital competences (MoNE, 2018) may not be classroom experiences for all students in Turkey.

Taken together, the results of this study suggest that if the goals of teaching mathematics are to help students to be mathematically literate and to understand mathematical concepts and use them in daily life, and to express mathematical reasoning in problem solving processes (MoNE, 2018), then students must be supported to develop these skills. One of the key policy priorities should be to investigate possible sources of students' mathematics classroom perceptions found in this study and take measures to improve them.

Conclusion and Direction for Future Research

The aim of this article was to investigate Turkish lower secondary students' perceptions of teaching and learning practices in mathematics classrooms. The students depicted mathematics teachers as transmitting information and demonstrating correct solutions while students are passive recipients. The drawings and associated texts, however, represent student responses at that point in time and within that classroom context. Other mathematical practices may exist but were not mentioned by the students so cannot be excluded. A second limitation relating to external validity also exists. It is not known whether the students' perceptions of mathematics classroom practices found in this study are the result of the specific characteristics of schools who participated in this study, or whether they are representative of a general trend in the population from which the sample has been drawn. Thus, the findings may not be generalizable to other schools in Ankara or to other regions in Turkey. Nevertheless, the findings presented here provide valid and valuable insight into mathematics classrooms and contain several implications. Together the drawing data and students' descriptions of pictures, strengthen the validity of the study and the conclusions drawn.

The Draw a Mathematics Classroom Test and its coding schema have been developed based on an extensive literature review. Both instruments provide mathematics educators and researchers with a tool for obtaining and evaluating information on what classroom mathematics teaching look like from the student's perspective. Through their reflections on the research instrument, participant students have generated numerous insights into mathematical practices in schools in Turkey which has thrown up several questions in need of further investigations. First, in the current study, drawings as well as writing were used as a mechanism for collecting information from the study sample. Different results could be obtained using other forms of data generation, and I hope that other researchers would investigate that possibility. For instance, future studies involving classroom observations on the current topic could add to the understandings we have gained from the drawing task, and assist us to determine how their actual classroom experiences contribute to the development of student perceptions. Perceptions of phenomena are likely to differ according to the participants consulted within an environment (Beswick, 2007). That is, the teacher and individual students in a class may all have different conceptions of what goes on in the same learning environment (e.g., Kalyon, 2020). Second, teachers' conceptions of mathematics teaching and learning experiences are likely to be unique and hence worthy of future investigations. Most of the students in this study described their perceived classrooms in neutral statements, while several responses indicated that some of the students found their mathematics lessons "boring" (S13, grade 8, boy). Finally, further investigations into what students' preferred mathematics classroom learning environments might look like, and associations between student perceptions of classroom practices and their learning outcomes (e.g., achievement, attitudes towards, or interest, in mathematics) is strongly recommended.

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Student Attitudes Towards Learning Mathematics Through Challenging, Problem Solving Tasks: "It's so Hard– in a Good Way"

James Russo[*,a], Michael Minas[b]

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[*,a]**Corresponding Author:** James Russo..
Monash University, Australia..
E-mail: james.russo@monash.edu
ORCID: http://orcid.org/0000-0002-9855-7522

[b] Michael Minas. LoveMaths, Australia.
E-mail: michael.lovemaths@gmail.com

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Abstract

Despite a focus on teaching mathematics through challenging, problem solving tasks, there has been limited research into student attitudes towards these learning experiences. To address this gap in the literature, we asked 52 Australian primary students who had recently experienced mathematics taught in this manner to convey their feelings about learning through problem solving. Adopting a qualitative, exploratory, research design, student participants completed a brief questionnaire, and a sub-set also contributed to follow-up focus groups. Thematic analysis of the questionnaire data revealed that three-quarters of students reported unambiguously positive attitudes towards problem solving, most others were ambivalent, and no students expressed negative attitudes. Younger students (Year 3/4) were more likely to express positive attitudes than older students (Year 5/6) and boys more likely to express positive attitudes than girls. Positive attitudes arose from students enjoying learning through problem solving, the perception that it supported their learning, and students thriving on challenge. Follow-up focus groups also reinforced the power of working collaboratively, particularly the importance of learning through discussions with peers, and opportunities to explore authentic and purposeful tasks. The findings help explain why students frequently have positive reactions to learning mathematics through problem solving.

Keywords:
Challenging Tasks, Mathematics Education,
Problem Solving, Student Attitudes, Student Enjoyment

Introduction

The quality of tasks that students engage with in the classroom has been widely acknowledged as critical to supporting student mathematical learning (Anthony & Walshaw, 2010). Consequently, "selecting, designing, and modifying tasks for teaching" is central to the practice of all teachers of mathematics (Tekkumru-Kisa et al., 2020, p. 3). Indeed, teaching with more cognitively demanding tasks through problem-based learning approaches has been an important aspect of efforts to reform mathematics education in many countries, including: Australia (Sullivan et al., 2016, 2020), Indonesia (Siagan et al., 2019; Simamora

& Saragih, 2019), Sweden (Samuelsson, 2010), Turkey (Bulut, 2007), Portugal (Viseu & Oliveira, 2017), the United Kingdom (Boaler 1998, 2000), and the United States (Stein & Lane, 1996; Stein et al., 2008), to name but a few. On occasion, teaching mathematics through problem solving has been augmented by efforts to simultaneously develop students' meta-cognitive problem solving skills, so that they can engage more productively in cognitively demanding tasks (Özsoy & Ataman, 2009). Teaching mathematics through challenging, problem-solving tasks has been shown to support student learning through: encouraging students to connect mathematical ideas (Loibl et al., 2017); promoting the transfer of problem solving skills (Kapur, 2010); cultivating critical thinking skills and mental flexibility (Leikin, 2014); supporting mathematical creativity and discourse (Russo & Hopkins, 2017a); and developing problem solving skills (Karatas & Baki, 2013).

Despite evidence for their impact on student learning, there have been relatively few studies examining student experiences with challenging, problem solving tasks (Tekkumru-Kisa et al., 2020). Although some teachers are hesitant to introduce such challenging, problem solving tasks to all students regardless of their perceived mathematical ability (Ingram et al., 2019; Leikin et al., 2006), there is evidence that many students' embrace struggle and thrive on challenge (Russo & Hopkins, 2017b; Sullivan & Mornane, 2014). Previous studies that have discussed student attitudes to problem solving in an Australian educational context have focused on early primary (i.e., Year 1, Year 2; Russo & Hopkins, 2017b) or secondary (i.e., Year 8; Sullivan & Mornane, 2014, Year 10; Wilkie, 2016) contexts. The current research-practice partnership endeavoured to add to this existing literature through examining the attitudes of middle and upper primary students (Years 3 to 6) to learning mathematics through challenging, problem solving tasks.

Background Literature

Attitudes refer to ways in which individuals may act, feel, or think as a means of expressing their view (positive or negative) about a particular topic. They are considered more enduring and cognitive than emotions, but less enduring and cognitive than beliefs (Philipp, 2007). Student attitudes have been an increasing focus of research into mathematics education over the past two decades. Relevant to the current study, there is a growing body of literature connecting instructional approaches focused on learning mathematics through problem solving with positive attitudes towards mathematics learning (Chen et al., 2015; Chew et al., 2019; Hendriana et al. 2018; Higgins, 1997; Ni et al., 2018). However, as many of these studies have adopted quantitative methods, they have tended to not probe the specific reasons for these positive attitudes, nor to delve into the experience of learning mathematics in this manner from the perspective of the student. By contrast, three recent studies have focussed on student reactions to learning mathematics through challenging, problem solving tasks in an Australian context in particular, and have incorporated some qualitative methods to explore explanations for these reactions.

Russo and Hopkins (2017b) interviewed 73 Year 1 and Year 2 students following their engagement in a unit of work (16 lessons) built around challenging, problem solving tasks. The associated classroom teachers involved in the study confirmed that students certainly experienced the tasks as cognitively demanding, and students frequently worked on the tasks for periods of 20 minutes or more without identifying any solutions (Russo & Hopkins, 2019; Russo, 2019). During the interviews, students were encouraged to sort through the work artefacts they created during the unit to prompt reflection. The authors concluded from their analysis of student responses that these young students embraced struggle and persisted when engaged in mathematics lessons involving challenging tasks, and moreover that many students enjoyed the process of being challenged.

Sullivan and Mornane (2014) led a design-based research project that supported five junior secondary teachers (Year 8) to deliver a unit of work built around challenging, problem solving tasks. This support included a workshop where the pedagogical approach was discussed and unpacked, a booklet of task ideas, and a demonstration lesson in the classroom. Part of the data collection process involved gathering student affective responses to the demonstration lesson in particular, and learning mathematics through challenging tasks more generally. The most frequently chosen words to describe how students felt working on such tasks were: challenged, interested and confused. Combining specific student reactions to two particular tasks, the authors noted that most students (53%) felt that working on these tasks was the 'same as usual', with some students (22%) responding that they liked/ preferred these tasks more than usual, and some students responding they liked/ preferred these tasks less than usual (24%). Sullivan and Mornane (2014) concluded from their study that "teachers' possible fears of widespread negative student reaction to challenge are unfounded" (p. 207).

Wilkie (2016) undertook a similar design-based project with 87 high-achieving senior secondary students (Year 10) and their respective teachers aimed at supporting teachers teach mathematics through challenging, problem solving tasks. Following observing a particular lesson involving a quadratics task, the researcher had students complete a questionnaire to describe their reactions to the task. Wilkie's analysis revealed that most student descriptions of their reactions tended to emphasise affect (i.e., how they felt about their learning) rather than cognition (i.e., level of perceived challenge and the effectiveness of the task to support learning). Moreover, the vast majority of affective reactions to the task were positive (e.g., interesting, engaging, enjoyable, fun, good), and almost all the remaining reactions neutral (i.e., okay, alright). Only one student responded negatively to the task (i.e., being confused).

Theoretical Framework

Despite teacher concerns to the contrary, there is evidence to suggest that students often have positive attitudes towards learning mathematics through problem solving, particularly when enabling and extending prompts are used to augment the level of challenge (Russo & Hopkins, 2017b; Sullivan & Mornane, 2014; Wilkie, 2016). Enabling prompts make the task more accessible to students who require further support through: simplifying the problem, changing how the problem is represented, helping the student connect the problem to prior learning and/or removing a step in the problem (Sullivan et al., 2006, 2009). Extending prompts extend the task, or expose students to a similar task, that is more challenging, often to prompt generalising (Sullivan et al., 2006, 2009).

Self-determination theory can be used to help us understand why many students might enjoy learning mathematics through challenging, problem solving tasks, more than through more traditional instructional approaches (e.g., teacher explanations, followed by practice of more routine problems). Advocates of self-determination theory contend that there are three fundamental psychological needs that motivate behaviour: autonomy, competence and relatedness (Deci & Ryan, 2012). It can be argued that lessons involving challenging, problem solving tasks can support students in meeting all three of these needs.

First, working on challenging tasks promotes autonomy. Students have a choice over how they approach a task (Sullivan & Mornane, 2014), are frequently invited to solve a task in multiple ways (Russo et al., 2019), and, in many contexts in which these tasks are used (including the current study), are able to access enabling and extending prompts of their own volition (Russo et al., 2020). Second, working on challenging tasks promotes competence. Students have a strong sense that challenging, problem solving tasks are simultaneously more demanding, yet more worthwhile and authentic than more routine mathematical work. Consequently, students who make progress with challenging tasks frequently experience a sense of pride and accomplishment (Russo & Hopkins, 2017b). Third, working on challenging tasks promotes relatedness. In lessons involving challenging tasks, inviting students to collaborate when exploring a task tends to be an important component of the overall lesson structure (Russo, 2020). Allowing students to collaborate after spending some initial time working individually on the task was indeed how challenging tasks were used with students in the current study.

The current qualitative, exploratory, study investigated the attitudes two classes of primary school students (Years 3 to 6) had towards learning mathematics through challenging, problem solving tasks. We were interested in exploring the reasons underpinning these attitudes, as well as whether differences existed in attitudes across grade level and gender. Our study adds to the existing literature, due to both the qualitative methodology adopted, and the age group of the students.

Method

Participants

Two classes of students (*n*= 52) from one particular school completed a questionnaire after participating in a lesson involving problem solving. Participating students included one Year 5/6 composite class (26 students), and one Year 3/4 composite class (26 students). The school was a medium size primary school (approximately 300 students) situated in outer North-Western Melbourne. Its demographic profile was comparable to Australia as a whole, with most students being classified into the middle quartiles on the measure of community socio-educational advantage (67%). All students completed the questionnaire, which was returned anonymously.

School Context

According to the National Assessment Program – Literacy and Numeracy Assessment (NAPLAN) data, the school can be classified as an average-performing school in terms of its academic achievement, which is consistent with its demographic profile being reflective of Australia as a whole in terms of its relative advantage. Anecdotally, it is worth noting that there was relatively limited parental involvement in student learning at the school, and no specific initiatives to address this issue. Class sizes were between 25 and 30 in the middle and upper primary years.

Over the previous two years, most of the professional development that the school engaged with was focussed on a "visible-learning" approach, loosely based on John Hattie's work (Hattie, 2012). This meant that significant emphasis was placed on areas such as learning intentions, success criteria, goal setting and growth mindsets.

As a result of this focus on "visible-learning", there had been comparatively little time devoted to professional development in the area of mathematics. The school was a member of a Number Intervention project run by Catholic Education Melbourne. The program targets a small section of students from Year 1 to 4 to participate in an intervention program designed to address specific learning needs. However, only two staff members were directly involved in its implementation, therefore, it did not have an impact on the wider student population or the pedagogical approach of the bulk of the classroom teachers.

At the time of this study, the school had recently appointed a new mathematics leader (second author). The focus of his work was in getting teaching staff to pay more attention to the proficiency strands of understanding, fluency, reasoning and problem solving (i.e., how mathematics was being taught), rather than almost exclusively focussing on the content of the curriculum (i.e., what needed to be taught).

Both classroom teachers involved in this study were graduates. The Year 3/4 teacher was in her first year working as a teacher, after graduating from university at the end of the previous year. At the time of the study, she was planning in a team with two other colleagues, both considerably more experienced. Prior to her involvement in this coaching cycle, she felt that her students had few opportunities to work as genuine problem solvers in her mathematics lessons. She was pleasantly surprised both at how engaged her students were during the problem solving lessons, as well as their capacity to make good choices in relation to their learning when given the opportunity to do so (e.g. choosing when to access enabling prompts, selecting peers to collaborate with).

The Year 5/6 teacher was in her second year working as a classroom teacher at the time of the study. She actively requested to be included in the school's mathematics coaching program, as many of her students had expressed to her that they were finding mathematics boring. She was also aware that she was having difficulty catering for the diverse range of student performance in her class, with some students complaining that the work her team was planning was too easy, while others were finding it so challenging that they were becoming disengaged from the subject. While her self-confidence in her ability as a mathematics teacher was somewhat low in the current context, she was open to new ideas and willing to trial different approaches in order to improve her practice.

Procedure

The second author was tasked with working once a week in multiple classrooms across a school term, with the objective being to model (for the classroom teachers) how to teach with challenging tasks using a task-first approach. Specifically, the lesson structure being modelled resembled the launch-explore-discuss/summarise structure that is often adopted when teaching mathematics in this manner (Stein et al., 2008).

Students were asked to provide a written response to the following question directly after such a problem solving lesson: How do you feel about learning mathematics through problem solving? In addition, six students (3 boys, 3 girls) from Year 5/6, and six students (3 boys, 3 girls) from Year 3/4, also participated in focus groups designed to explore in more depth students' feelings about learning mathematics through problem solving. Each focus group consisted of two students identified as relatively low-performing in mathematics, two students identified as average-performing in mathematics, and two students identified as high-performing in mathematics (as indicated by their classroom teacher).

In the Year 5/6 Case Study classroom, at the time of completing the questionnaire, students had experienced six lessons involving challenging, problem solving tasks: three modelled lessons led by the second author, and three lessons led by the classroom teacher. By contrast, in the Year 3/4 Case Study classroom, at the time of the questionnaire being administered, students had experienced approximately 25 lessons involving challenging, problem solving tasks: 10 modelled lessons led by the second author, and approximately 15 lessons led by the classroom teacher.

In both classrooms, this task-first approach differed greatly from what the vast majority of the students had previously been exposed to. In the past, the school favoured a more 'traditional' approach, where each lesson begins with the teacher modelling what the students will be working on, before the students are given time to apply the skill or concept independently.

Examples of Challenging, Problem Solving Tasks from The Study

The lesson that immediately preceded the administering of the questionnaire to the Year 3/4 class was based on a task developed by the second author. The main problem (see below) was launched with a brief story about a family vacation at a resort that had a large chess set. It was also accompanied with a picture of one of the children in the problem playing chess at the resort, which was placed on the classroom's television during the launch phase.

> *Main task: Nash, Isaiah, Genevieve, Rhia, Megan and Ava decided to play a round robin chess tournament during the week that they stayed at Paradise Resort. How many matches will they have to play for each person to play each other player once?*

The enabling prompt (see below), was placed on the teacher's chair, the same spot where it was placed during all problem solving lessons in this particular room. At the conclusion of a five minute period where students had to work both silently and independently, they were free to access this prompt at any time that they felt it would be helpful and to collaborate with others (note that this same basic protocol was followed in the Year 5/6 classroom).

> *Enabling prompt: Can you draw a diagram to show how many matches Nash plays, so that he played each of the other kids once? Can you do the same for Isaiah?*

The extending prompt (see below) for this particular lesson, asked students to extend their thinking from the initial problem, to see if they could make a generalisation about this particular type of problem.

> *Extending prompt: If there were 10 kids wanting to play a round robin tournament, how many matches will they have to play for each person to play each other player once? What if there were 20 kids? How about 100?*

The lesson that preceded the questionnaire in the Year 5/6 classroom was a modified version of Adding and Subtracting Fractions, a task found in Challenging Mathematical Tasks by Peter Sullivan. The main problem (see below), was identical to the original version.

> *Main task: Some parts of my equation below did not print. What might the missing numbers be?*

$$2\frac{\square}{4} + \frac{\square}{8} = 3\frac{\square}{\square}$$

> *Give as many answers as you can*

However, both the enabling and extending prompts (see below) were modified, in order to include specific direction for students to draw diagrams to match the equations they found. This was based around assessment information gathered from previous lessons, which indicated that the students needed more focus on building their conceptual understanding of fractions.

> *Enabling prompt: What might the missing numbers be?*

$$\frac{\square}{4} + \frac{\square}{8} = \frac{\square}{8}$$

> *Draw a matching diagram for each equation to prove that it is correct.*
>
> *Extending prompt: Choose 3 of your equations and record matching diagrams to prove that they are correct. Can you record your answers in a way that proves you have found all the possible combinations?*

Analytical Approach

Data was analysed thematically, following the process put forward by Braun and Clarke (2006). The process began by deeply immersing ourselves in the data, reading and rereading questionnaire responses and focus group transcripts to develop an overall impression. Following this familiarisation, we began our first level of coding by classifying each student questionnaire response according to the participants' overall attitude towards problem-solving: positive, ambivalent, negative, or a descriptive response – that is, no attitude could be gleaned from the text (see Table 1 and Table 2).

We then returned to the questionnaire data to begin our second level of coding, which involved identifying specific themes to explain these attitudes (see Table 3 and Table 4). These themes were then further refined, for example, in some instances two themes were combined when they were deemed conceptually closely related (e.g., persistence and confidence). Following this refining process, themes were then elaborated and more clearly defined through selecting a particular participant response that accurately captured that theme. The final list included nine themes, with many participant responses being coded to multiple themes. Finally, focus group transcripts were then reread, and selected quotations which connected to a particular theme were extracted and classified when relevant.

Results

Results of our analysis are presented below. Illustrative quotes from both the questionnaire text and the focus groups' are included in order to further illuminate key themes.

Table 1
Attitude to Problem Solving by Gender

	Positive	Ambivalent	Descriptive	Negative
Boys	21 (84%)	2 (8%)	2 (8%)	0 (0%)
Girls	18 (67%)	9 (33%)	0 (0%)	0 (0%)
Total	39 (75%)	11 (21%)	2 (4%)	0 (0%)

Table 2
Attitude to Problem Solving by Year Level

	Positive	Ambivalent	Descriptive	Negative
Year 3/4	23 (88%)	2 (8%)	1 (4%)	0 (0%)
Year 5/6	16 (62%)	9 (35%)	1 (4%)	0 (0%)
Total	39 (75%)	11 (21%)	2 (4%)	0 (0%)

Three-quarters of students described learning mathematics through problem solving in positive terms, whilst around one-fifth of students felt ambivalent. Boys were somewhat more likely to hold unambiguously positive attitudes (84% vs 67%) and girls somewhat more likely to be ambivalent (33% vs 8%; see Table 1). In addition, there was evidence that the Year 3/4 groups held more positive attitudes than the 5/6 group (88% vs 62%), and older students were more likely to be ambivalent (35% vs 8%; see Table 2).

Reasons for Positive Attitudes towards Problem Solving

As previously noted, 39 out of the 52 students held unambiguously positive attitudes towards learning mathematics through problem solving. As is apparent from Table 3, the reasons why students held these positive views varied considerably. It is worth reiterating that some student responses were coded to multiple themes (mean= 2.2 themes).

As is apparent from Table 3, two-thirds of students who held positive attitudes towards learning mathematics through problem solving indicated that they found the process enjoyable or fun; corresponding to half of students who completed the questionnaire. Ostensibly, in contrast, the third most prevalent theme identified was the notion that learning through problem solving is challenging or hard. However, further analysis revealed that 12 out of the 39 students with positive attitudes towards learning mathematics through problem solving (equating to 23% of all students) had their responses coded to both the themes enjoyable/ fun and challenging/ hard. The implication is that these students enjoyed learning mathematics through problem solving precisely because it was challenging. Here are some selected quotes from students who felt that it was the challenging nature of the tasks which made them enjoyable:

> *"I love it! It is so hard (in a good way) fun and interesting. I also love it because it is always true! Sometimes it's funny. Super duper fantastic." (Year 3/4 student).*

> *"It is really fun but sometimes it is a bit tricky and that's how math is. It is a bit of a challenge for me and I love a challenge." (Year 3/4 student).*

> *"I think that problem solving is really fun because it challenges me with my math - and because it is always different."(Year 5/6 student).*

> *"The problems are fun and a good challenge. I like it when I get stuck, but try something and it works. I like the problems with more than one answer to it..."(Year 5/6 student).*

> *"Problem solving is a lot of fun because it's not so easy and I like hard things." (Year 5/6 student).*

By contrast, here is an example of a quote classified to the challenge/ hard theme, but not enjoyment/ fun, for a student who held a positive attitude towards problem solving. In this example, it seems that the student values problem solving because they view it as good for their learning ("Supports mathematical learning"), rather than enjoyable/ fun:

> *"I like problem solving because it gives you a challenge and makes you think really hard - and I think that it is good for my learning." (Year 5/6 student).*

The idea that it is the challenging nature of this approach which makes it both an enjoyable and effective way to learn was a theme that also appeared in the focus group discussions. Below are some quotes from these discussions that illustrate how challenge contributed to the positive attitudes displayed by the students:

> *"I reckon today's session was actually pretty good because it was a bit confusing at the start, and then once you got the hang of it and started figuring out patterns, and it was really cool how it worked actually." (Year 3/4 student)*

> *"I felt like it was actually good because my brain keeps stretching every time I do problem solving, so I enjoy it." (Year 3/4 student)*

> *"I've learned more...because problem solving's actually hard." (Year 5/6 student)*

The second most prominent reason identified through the questionnaire responses as to why students were positive about learning mathematics through problem solving was the belief that this instructional approach supported their mathematical learning. During the focus group discussions, this theme was frequently raised in connection with the idea that students enjoyed working on problems with connections to real-world scenarios and that they also felt that these links to the outside world made the mathematics easier to understand.

> *"I like doing problem solving because it's like a scenario and there's a background story to the actual problem and it's not just like three times four, it's actually giving you a problem that's in a background story." (Year 3/4 student)*

> *"[Having a real-world scenario for the problem] makes it a bit more fun and a bit more easy to understand." (Year 3/4 student)*

Table 3

Reasons for Positive Attitudes towards Problem Solving: Summary of Thematic Analysis

Theme	*N*	Percentage of students with positive attitudes to problem solving	Percentage of all students
Enjoyable/ fun	26	67%	50%
Supports mathematical learning	16	41%	31%
Challenging/ hard	15	38%	29%
Opportunities to collaborate with other students	7	18%	13%
Relevant to real world and other curriculum areas	5	13%	10%
Interesting/ novel way of learning mathematics	5	13%	10%
Builds confidence/ persistence	5	13%	10%
Value the learning contexts in which the tasks presented	4	10%	8%
Opportunities to work independently and be autonomous	2	5%	4%

> *"It also helps, all the questions are things that could happen in real life. Like the problem that we had today." (Year 5/6 student)*

Another theme linked to positive attitudes towards this learning approach was the freedom to collaborate with peers. This was the fourth most frequently identified theme to emerge from our analysis of free text student questionnaire responses to their feelings about problem solving, after: "enjoyable/ fun", "supports mathematical learning" and "challenging/ hard". Moreover, this feedback was reported on many occasions to the second author through informal discussions with students and it also came up repeatedly in the focus groups. It seemed that allowing, or in some cases actively encouraging, students to work collaboratively with whomever they wanted was notably different to regular practice in each of the classrooms, and particularly valued amongst students in Year 5 and Year 6. Below are some quotes from the focus groups relating to collaboration:

> *"I think it's better how it is now sort of, because instead of Miss X taking students and sort of showing them how to do it... we're allowed to work collaboratively so each person sort of gives in an idea as well. So, you're thinking like, instead of Miss X thinking with your thinking, you're thinking with people who are the same age, same sort of thinking." (Year 5/6 student)*

> *"I like how it is now because when we got called to the floor I always feel like a bit self-conscious about where my learning was at with some of the things and I felt like I was sort of missing out on collaborating with people and friends and just trying to work out another problem. So, I like how it is now." (Year 5/6 student)*

> *"I kind of find it better when my friend's showing me something than like a teacher, because my friends kind of show me how it's done, but I I kind of listen to them more than a teacher." (Year 5/6 student)*

> *"We learn best off each other." (Year 5/6 student)*

Reasons for Ambivalent Attitudes towards Problem Solving

By contrast, 11 out of the 52 students held ambivalent feelings about problem solving. Table 4 indicates the themes to which these student responses were coded. Again, some student responses were coded to multiple themes (mean = 1.9 themes).

It was interesting to note that challenging/ hard was the major reason why some students felt ambivalent about learning mathematics through problem solving. Here are some quotes from students classified as ambivalent who noted challenge as a contributing factor:

> *"I think that some of the problems that we get are a little bit too hard sometimes, because they are a little bit too challenging. At the same time, they are also good because it really helps us learn more and challenges us." (Year 5/6).*

Table 4

Reasons for Ambivalent Attitudes towards Problem Solving: Summary of Thematic Analysis

Theme	*N*	Percentage of students with ambivalent attitudes to problem solving	Percentage of all students
Challenging/ hard	8	73%	15%
Sometimes it is enjoyable, other times it is not	5	45%	10%
Sometimes interesting, but too much problem solving can become boring	3	27%	6%
Opportunities to collaborate with other students	3	27%	6%
Builds confidence/ persistence	2	18%	4%

> *"I'm not very good with problem solving so I find them a bit tricky. I get a little bit stressed about it - that I'm not going to work it out." (Year 5/6)*
>
> *"When our class does problem solving, I say I don't want to do it - but when we get into it, I find it really fun... But when we do fraction problem solving I get frustrated because I don't get it." (Year 5/6).*
>
> *"Problem solving makes me feel happy, sad, good, annoyed. Sometimes I feel like quitting but I don't" (Year 3/4)*

However, it is important to note that although challenge/ hard was the most prevalent theme explaining students' ambivalence, students who indicated that learning through problem solving was challenging/ hard were more likely to hold positive attitudes towards problem solving (15/23; 65%) than be ambivalent (8/23; 35%).

Discussion and Conclusions

Consistent with our theoretical framework linked to self-determination theory (Deci & Ryan, 2012), the current study found that most primary school students (75%) conveyed unambiguously positive attitudes towards learning mathematics through challenging, problem solving tasks. Moreover, approximately half of students indicated that they found learning mathematics in this manner enjoyable and/ or fun. This is consistent with prior research. For example, 28 out of the 73 (38%) students in the Russo and Hopkins (2017b) study indicated that they valued work on challenging mathematics tasks because they enjoyed it. Moreover, in a similar manner to Russo and Russo (2020), around one quarter of our study participants indicated that they enjoyed learning mathematics through problem solving tasks precisely because it was challenging and hard. This supports the claim that working on such tasks helps to meet students' need for competence (Deci & Ryan, 2012).

Other prominent themes included the notion that this instructional approach supported students' mathematics learning, in part through providing meaningful problem contexts to make mathematical ideas more salient. Students also valued the opportunity to work collaboratively with peers, with several focus group participants in particular noting that peer explanations were often clearer and more comprehendible than teacher explanations. The emphasis on the value of peer collaboration suggests that learning mathematics through challenging, problem solving tasks also supports students' need for relatedness (Deci & Ryan, 2012).

Conversely, slightly less than one quarter of students were ambivalent about learning mathematics through challenging, problem solving tasks. Most students with these ambivalent attitudes indicated that they felt this way because learning mathematics through problem solving was challenging and/ or hard. It is noteworthy, however, that a student who reported learning in this manner to be challenging and/ or hard was still approximately twice as likely to have an unambiguously positive attitude towards problem solving than be ambivalent. Moreover, perhaps surprisingly, no students in our study reported unambiguously negative feelings towards learning mathematics through challenging, problem solving tasks. Although replicating this finding in other contexts with larger and more diverse samples of students is necessary, this suggests that it is relatively unusual for primary-aged students to hold negative attitudes towards problem solving.

There were some differences in the propensity to report positive attitudes towards problem solving between grade level and gender that are worth drawing attention to. Previous studies have discussed how younger students have tended to report higher levels of enjoyment and intrinsic motivation to learn mathematics compared with older students (Lepper et al., 2005; Russo & Russo, 2019). Our findings suggest that this claim can be extended to learning mathematics through challenging, problem solving tasks. In relation to gender, some previous studies have found that boys have more positive attitudes towards learning mathematics than girls (Skaalvik & Skaalvik, 2004), however other studies have failed to find meaningful overall differences across gender (Mata et al., 2012). We found that boys were more likely to hold unambiguously positive attitudes towards learning mathematics through challenging, problem solving tasks than girls. It might be interesting to attempt to replicate this finding with a larger sample, and explore the underlining mechanisms in more depth (e.g., Are boys more likely to report enjoying mathematics learning experiences that are challenging or hard than girls?).

Our study has particular limitations that need to be acknowledged. First, the study needs to be considered exploratory in nature, as the school and student participants were selected on a convenience basis. Future studies intending to examine the issue more systematically may consider different sampling procedures (e.g., random sampling). Secondly, it is possible that the second author's pre-existing relationship with the school and students may impact student responses, particularly during the focus groups (e.g., social desirability bias). However, it should be noted that having a pre-existing teacher-student relationship can also be considered a strength of the current study design, as this established trust might encourage students to be more candid and thoughtful with their responses.

To conclude, despite teacher concerns to the contrary (e.g., Ingram et al., 2019), the current study affirms the idea that primary students embrace learning mathematics through problem solving tasks; at least in a context where such tasks are augmented by enabling and extending prompts (Sullivan et al., 2009), and students are afforded opportunities to work collaboratively. These overwhelmingly positive student attitudes should embolden teachers to experiment with such approaches in their own classrooms.

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What Makes A Great Preschool Teacher? Best Practices and Classroom Quality in an Urban Early Childhood Setting

Charles J. Infurna*

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*,a Correspondance Details: Charles J. Infurna. Children's Institute, Department of Clinical and Social Sciences in Psychology, University of Rochester, USA.
E-mail: cinfurna@childrensinstitute.net
ORCID: http://orcid.org/0000-0001-9960-440X

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Abstract

This qualitative study explored preschool teacher beliefs and practices in relationship to observed classroom quality and student outcomes. A phenomenological approach framed the design of the research collected from seven preschool teachers in a large urban school district in Western NY. Teachers were asked two questions about student learning and excellence in teaching. Findings suggest that high performing preschool teachers believe it is important to establish nurturing relationships with their students, foster positive relationships with the families of the children they work with in the classroom, and nurture the social-emotional development of their children in the classroom. Pedagogically, differentiated instruction emerged as a theme in which teachers' described their teaching practice to meet the needs of all their students. Future research should be focused on the impact professional development has on the quality of instruction provided in preschool classrooms.

Keywords:
Early Childhood Education, Social-Emotional Development,; Classroom Quality, Qualitative Study, Preschool Education

Introduction

In 2014, approximately one million four-year old children attended one of 40 state-funded preschool programs in the United States (Barnett, Carolan, Fitzgerald, & Squires, 2012). However, only 30% of eligible students are enrolled in high quality early childhood education programs (Huang, 2017). Given the recent increases in state and community budgets for early childhood education programming, evidence on the causal effects of preschool are essential in order to justify the continued support for the expansion and improvement of high quality preschool initiatives in the United States. One such problem is the direct relationship between early childhood education classroom quality and student outcomes of universal prekindergarten students (Huang, 2017; Early, Maxwell, Ponder, & Pan, 2017; Perlman et al., 2016).

High-quality early childhood education experiences help shape and influence children's readiness for school, as well as later life outcomes (Campbell et al., 2012). Similarly, the early childhood care landscape has been marked by low quality and inconsistent fidelity in education and care, which has historically been a fiscal burden on local municipalities and communities alike (Barnett et al., 2010). For these reasons, the past two decades have seen greater investments made in the opportunities to provide affordable high-quality early childhood education opportunities that meet stringent national and state regulations through increased amounts of accountability (Bassok, Fitzpatrick, Greenberg, & Loeb, 2016).

One of the primary goals of state and local initiatives is to improve the quality of early childhood education programming (Early et al., 2017). Empirical research studies conducted over the past two decades have shown that student outcomes are positively associated to high quality early childhood education programming (Broekhuizen, Mokrova, Burchinal, Garrett-Peters, & The Family Life Project Key Investigators, 2016; Barnett et al., 2012. There is overwhelming support for the developmental importance of high-quality early childhood education settings being predictive of cognitive and social-emotional development in three and four-year old children (Weiland, Ulvestad, Sachs, & Yoshikawa, 2013).

Literature Review

A plethora of empirical studies have examined the association between classroom quality and student outcomes (Early et al., 2017; Broekhuizen et al., 2016; Hatfield, Burchinal, Pianta, & Sideris, 2016; Weiland et al., 2013; Dennis & O'Connor, 2013). Although theory and research suggest that high-quality early childhood experiences positively influence children's school readiness as they transition to kindergarten (Bassok et al., 2016), the relationship between measures of classroom quality and school readiness are inconsistent in the empirical literature. Contradictory findings exist among studies using the CLASS to measure teacher effectiveness; a measure that is widely regarded as a valid measure of quality in the early childhood education setting.

A widely used classroom quality assessment tool is the Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Harme, 2008). The CLASS is made up of three developmental domains; Emotional Support, Classroom Organization, and Instructional Support. The Emotional Support domain measures the emotional connection between teacher and student, teachers' awareness to student academic and/or social-emotional concerns, and the emphasis placed on developmentally appropriate activities that meet the interests of students. The Classroom Organization domain of the CLASS measures how the teacher handles disruptions, how well the classroom functions, and how teachers facilitate activities that stimulate student learning and development. The Instructional Support domain of the CLASS measures how teachers use instructional discussions to foster student higher-order thinking skills, extended conversations between teachers and students, and how teachers facilitate student language development.

The quality of the classroom atmosphere has been measured by two domains of the CLASS, primarily the emotional support and instructional support domains (Mashburn et al., 2008). The emotional support domain measures the extent to which teachers are emotionally engaged with their students. The instructional support domain measures the verbal interactions between a teacher and their students. Teachers who were rated as providing instructionally supportive classroom environments did so by asking open-ended questions, engaging their children in continuous feedback loops, and used scaffolding concepts of instruction (Mashburn et al., 2008; Pianta et al., 2008). Emotional support and the instructional support domains of the CLASS have been associated with student achievement in the empirical research conducted in the United States (Pianta et al., 2008; Pianta, La Paro, Payne, Cox, & Bradley, 2002; Mashburn et al., 2008).

In a study measuring classroom quality in prekindergarten classrooms, Mashburn et al., (2008) reported that the instructional support domain of the CLASS was positively associated with five measures of student cognitive and language development. In a study examining preschool teacher self-efficacy, classroom quality, and children language and literacy gains, Guo, Piasta, Justice, and Kaderavek (2010) reported that HLM results demonstrated that instructional support (μ_{02}= 1.005, $t_{(63)}$= 1.912, p= .06) and emotional support (μ_{02}= 1.021, $t_{(63)}$= 1.970, p= .05) domains of the CLASS exhibited positive trends towards significantly predicting change in children's vocabulary knowledge (Guo et al., 2010). However, Guo and colleagues (2014) reported that neither instructional support (μ= 1.62, p= .46) or emotional support (μ= 1.73, p= .41) domains of the CLASS significantly predicted change in children's language scores. Similarly, children's literacy scores were not affected by the instructional support (μ= .18, p=.93) or emotional support (μ= 1.96, p= .32) domains of the CLASS.

A meta-analysis review conducted by Perlman, Falenchuk, Fletcher, McMullen, Beyene, and Shah (2016) reviewed 35 studies associated with classroom quality and student outcomes. Perlman et al., (2016) reported that no significant associations were found between the Emotional Support domain of the CLASS and student outcomes. However, significant but small correlations were found between the Classroom Organization domain of the CLASS and student outcomes. Similarly, the Instructional Support domain of the CLASS was significantly but weakly correlated to the SSRS Social Skills subscale. The relationship between Instructional Support and PPVT, WJ Letter Word ID, and WJ Applied Problems were not significant. Essentially, the connection between classroom teaching observation measures and child growth towards kindergarten readiness is much weaker than the commonly accepted theories of education predict (Bassok et al., 2016; Guo et al., 2014; Guo et al., 2010; Justice, Mashburn, Hamre, & Pianta, 2008).

The purpose of this study is to determine teachers' working theory about the connection of teaching and learning among UPK teachers based on their pattern of observed classroom quality and growth in child outcomes. Many previous quantitative studies have sought to link child outcomes with classroom quality with mixed results (Huang 2017; Bassok et al., 2016; Perlman et al., 2016; Guo et al., 2014; Son et al., 2013). However, the current gap in empirical research is qualitative studies focused on early childhood educators and their perceptions of student learning (Son et al., 2013). Our proposed study fills the gap in the current literature, with the intention of better identifying the link between child outcomes and classroom quality through the voice of the teachers (Infurna, Riter, & Schultz, 2018; Mihai et al., 2017; Sherfinski, 2017; Chapman, 2016).

Method

Setting

A focus of the Rochester community for the past two decades has been to increase the quality of early childhood education programming. Each year, approximately 3500 three and four-year old children are enrolled in full day early childhood education programming provided by the Rochester City School District, Community Based Organizations (CBO), and Head Start (Infurna et al., 2016). Teachers are tasked with completing cognitive and social-emotional assessments on their children in the fall and spring of the academic year. Early childhood education teachers are also observed each year, with the CLASS assessment serving as an indicator of classroom quality.

RECAP began in 1992 as a collaboration of the United Way of New York State, the Rochester Area Community Foundation, the Rochester City School District (RCSD), the Center for Governmental Research (CGR), Action for a Better Community (ABC), and Children's Institute. Since its inception, one of RECAP's overall guiding tenets has been to continuously promote, ensure, and improve the quality of pre-k classroom experiences through the use of an integrated and comprehensive information system. Student outcomes and classroom quality have been two of the main tenants of the RECAP project. However, with over two decades of student and classroom data, a significant link between classroom quality and student outcomes has not been able to be made (Infurna et al., 2018; Infurna et al., 2016). For a deeper description of the RECAP project refer to Montes, Weber, Infurna, Van Wagner, Zimmer, and Hightower (2017).

Theoretical framework

We employed a phenomenological qualitative research approach (Creswell, 2013). The phenomenon in review for the purpose of this study is focused on the link between measured classroom quality and student outcomes at the preschool level. Our aim is to identify processes preschool teachers in an urban school district implement to make meaning of the connection between teaching and learning in preschool.

Participants

Participant—preschool teachers

There were a total of seven preschool teachers that participated in this qualitative study. They consisted of four preschool teachers employed by Community Based Organizations (CBOs) and three school based preschool teachers. In total, six preschool teachers were female and all teachers were Caucasian.

Participant—researcher

Research was conducted from January 2019 to November 2019 by one researcher and three research assistants. Research assistants corresponded to potential participants via email. The research assistants each conducted two interviews. The researcher and lead author conducted one of the interviews.

Data Collection

Semi-structured interviews consisting of open-ended questions were conducted between January 2019 and November 2019. Preschool teachers were randomly selected to be contacted to participate in the research study. Teachers that were randomly selected were emailed an outline of the proposed study and a copy of the interview questions. In total, seven preschool teachers participated in the study. Preschool teacher demographic information was collected prior to the interview taking place (see Table

1). This study was part of a larger RECAP study in which teachers were asked about the support they receive from their technical support teachers and mentors (teachers and administrators). The responses to those questions were not made part of this qualitative study. To identify a potential link between classroom quality and student cognitive growth and development over the course of the preschool year, additional assessment data was reviewed from a larger on-going longitudinal study (Infurna et al., 2016; Montes et al., 2017). Preschool teacher CLASS (Pianta et al., 2008) outcomes from the 2016-17 academic year was included (see Table 1). The CLASS is a widely implemented classroom quality tool used to measure the quality of early childhood education programming (Perlman et al., 2016). Student data was reviewed to explore the possible connection between teacher responses and student growth over the academic year (see Table 1). The Child Observation Record-Advantage (COR-Advantage; HighScope, 2014) measures eight developmental categories devised of 34 individual items. Preschool teachers collect COR Advantage data at three time points during the academic year (November, March, June). For a more detailed overview of the COR Advantage refer to Wakabayashi, Claxton, & Smith (2019) and Infurna et al., (2016).

Each research assistant conducted two preschool teacher interviews between January 2019 and June 2019. The lead author conducted one interview in November 2019. Upon receiving consent to participate in study, the research assistants and lead researcher scheduled dates and times for the interviews to be conducted. As part of a larger RECAP qualitative project, only responses from two questions were incorporated in this study; what do you do as a teacher that helps children learn the most?, and what does being a great teacher mean to you? Follow-up questions were asked to ensure clarification and elaboration of initial responses. All of the interviews were conducted in person at a mutually agreed upon time and location. Each interview was tape recorded. The interviews were then transcribed verbatim.

Data Analysis

Transcribed interviews resulted in 52 pages of single spaced text. Through repeated and careful examination of the data, common themes and higher order themes emerged (Patton, 2001). The researcher met with the research assistant that conducted the interview to ensure findings were accurate. The researcher and research assistant began developing themes reviewed from the individual transcript. After all seven interviews were conducted, the lead researcher and research assistants carried out a peer debriefing, which included a review of the transcripts and the development of themes. Saturation was reached at the conclusion of reviewing the seventh preschool teacher transcript (Patton, 2001). This process allowed the lead researcher to understand the teacher responses and each individual teacher's perspective on what it is like to be a preschool teacher in an urban school district in Western, NY.

Results

The findings are presented as a set of four higher order themes. The four higher order themes that emerged were; 1) social-emotional development, 2) establish relationships with families, 3) foster and nurture relationships with students, and 4) differentiate instruction to meet the needs of children.

Social-Emotional Development

Social-emotional development was a topic discussed in some detail by all seven of the preschool teachers that participated in the study. Several professional development offerings have been provided to preschool teachers in this community over the past three years which focused on trauma informed care and Pyramid Model (Infurna et al., 2018; Hemmeter, Fox, & Snyder, 2014) training. Teacher 2, a teacher with a very high CLASS score and moderate student COR-Advantage COR said, "The most important aspect, and it's tied to the beginning of my answer, it's the social-emotional piece so that children feel safe,

Table 1
Teacher Demographic Information

Teacher	Location	Gender	CLASS Score	COR Advantage Growth
Teacher 1	School Based	Female	6.9	2.3
Teacher 2	School Based	Female	6.7	1.1
Teacher 3	School Based	Female	6.5	1.6
Teacher 4	CBO	Male	6.5	1.6
Teacher 5	CBO	Female	6.3	1.8
Teacher 6	CBO	Female	6.0	0.7
Teacher 7	CBO	Female	5.1	1.5

secure, confident, and competent in their ability to be heard and take care of themselves in the classroom." Similarly, Teacher 6 said, "We're teaching them (students) numbers, but even more so social-emotional skills so what we're doing is teaching them how to share, how to solve a problem." Likewise, Teacher 4 said, "There's a lot of significance in the classroom ecosystem and the relationship between teacher and student...working on building social-emotional skills and how to navigate conflict."

Conflict resolution was discussed in a similar fashion as social-emotional development. A facet of the HighScope curriculum (HighScope, 2014) that is embedded for preschool teachers is a series of activities and lessons focused on conflict management. When the preschool teachers made reference to the importance of social-emotional development, it was followed-up with an idea about managing conflict in the classroom. Teacher 4 said, "We are working on friendship skills, working on how to negotiate conflict, and learning how to be a kind person in our classroom." Teacher 1, a school based teacher with an exemplary CLASS score and high student growth as measured by the COR-Advantage said, "We have a cozy cube area in our classroom. If we didn't have a cozy cube, we would have three children in our classroom that would not be where they currently are socially and emotionally. It is a place for them to cool off." For reference, a cozy cube area is an area of the classroom in which child are able to move to in order to self-regulate their emotions when they feel they need to cool off or relax. As part of the HighScope (2014) curriculum, preschool programs are encouraged to provide space in each classroom in which a child is able to move to in order to regulate their emotions. When asked about social-emotional strategies, Teacher 6 said, "So we're teaching them to try and solve their problems by themselves. So they also know that let's say two kids are crying over a toy, I approach them (the kids) and review the six steps of conflict resolution with them." Similarly, Teacher 4 said, "So much social and emotional growth is happening in the preschool year. I do a lot of work focusing on the development of self-worth and self-respect. Working on building concepts of self-esteem and empowerment, empowering students to think critically and be in control."

The Pyramid Model (Hemmeter et al., 2014) provides early childhood education teachers with strategies that they can implement when discussing social-emotionally learning. When asked a follow-up question about social-emotional learning, Teacher 5, a community based preschool teacher with a high CLASS score and high student growth as measured by the COR-Advantage said, "I have a lot of social stories I use. Especially at the beginning of the year, we talk a lot about how to be a super friend, different super powers we have, and how if someone takes a toy from you, do we just grab it? And we do, we act stuff out." Teacher 4 said, "I think there's so many other ways engaging in meaningful conflict resolution, engaging in other levels of that self-esteem component, that development of the self-component." He continued, "Again, talking about differences but having...I find a lot of importance in having honest conversations with my kids." Teacher 2 talked about research-based practices when discussing social-emotional learning. She said, "Helping children's social-emotional development, that's a mistake in behavior in that child. Just like you would teach the child how to spell their name and the letters in their name, you would teach that child on how best to communicate what it is they want."

Establish Relationships With Families

Although a formal question about establishing relationships with families was not included in the interview protocol, it was a talking point for all seven teachers that participated in the study. When asked about what it means to be a great teacher, all the participants made a reference to the importance of establishing positive relationships with the families of the children in their classroom. Teacher 3, a school based teacher with a high CLASS score and high student growth as measured by the COR-Advantage said, "Being a good teacher is somebody who's a team player...you've got parents and families that you need to work together for the success of each child." She continued, "I think understanding the whole family dynamics, and then being able to take that information and actually gear it toward the child, would be helpful in their learning." Teacher 4 said, "Of course academics are important and...the ability to help students grow academically also is based in having strong relationships with them. Of course that extends to strong relationships with families as a part of that team."

The implementation of technology is a strategy that one teacher discussed when developing relationships with families. When asked about building rapport with families, Teacher 5 said, "I use an app called Seesaw. I post pictures of the kids. I pretty much write what we're doing every week, what we did that week." Another strategy a teacher shared was to be an active listener when parents meet with you. Teacher 3 said, "When my school families come in and visit, try and have an open dialogue with your families. Try to keep it light, and when you can see somebody's really hurting, ask them if they would like to talk. You can step aside and be a listening ear." Another way a teacher helps develop a positive working relationship with families of his students is by communicating with them in their native language. Teacher 4 said, "I just took a Spanish class at MCC this past semester, because I have some

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Spanish speaking families and I think it's important to be able to talk to Grandma when she picks up."

Foster and Nurture Relationships with Students

When initially asked what being a great teacher meant to them, most of the preschool teachers that participated in this study made reference to fostering and developing relationships with the children in their classroom. Teacher 2 said, "First of all, it means being present for your children. It means knowing your children. So, knowing their needs, their learning styles, their interests." She continued, "First and foremost is having a relationship and building trust with your children, your students to let them know that that when they are with you, they're number one, they're safe." Teacher 3 continued, "I think probably looking at each child individually, particularly in pre-k, each child is coming in totally different than each...Every child is different that comes in." Similarly, Teacher 5 said, "I think it's just getting to really know your kids and just building a relationship with them. For me personally, I don't feel like we can really get into the academics until I really know my kids."

Looking from a broader classroom perspective, Teacher 4, a male community based teacher with a high CLASS score and high student growth as measured by the COR-Advantage said, "I think really...part of being a great teacher is an ability to connect individually with of your students, forming a special bond, then also as a whole group, as a whole classroom community." She continued, "I have 17 individual relationships with our class as a unit. I think those relationships are kind of paramount in the ability to then...do teaching." Teacher 6 also has a similar perspective as building community within her classroom. She said, "You know building relationships with them and they build relationships with each other because you can see like now once we go they give each other hugs and say hi, when they come in they're all excited. They made friends. That's great." Teacher 7 said, "Making a positive impact on someone. Being there for them. Oh gosh, I don't feel like...there's so many words. It's just everything that a teacher is, you know. You're their friend, their caretaker, their person that listens to them, that guides them."

Another teacher shared some strategies in which she helps establish and build relationships with kids. Teacher 1 said, "They're used to being heard, but not really listened to." When asked about a specific strategy she implemented about ways she listens, Teacher 1 said, "They're not used to the language coming back to them and taking them further when they have a problem. They're usually used to maybe more louder voices, so they don't understand the difference between; that I'm not angry, I'm trying to help you solve your problem." She continues, "Once you start actively listening, they realize you're hearing them and you're listening to them." Teacher 6 summed it up by stating, "It's really important to show that you care because they need to know you care about them."

Differentiate Instruction to Meet the Needs of Children

As is similar to the other three higher-order themes, all seven preschool teachers shared ways in which they were able to differentiate their instruction to meet the needs of their children. When asked how she differentiated instruction in her classroom, Teacher 1 shared an example of meeting the unique needs of two children in her classroom. Teacher 1 said, "I have two children with no language skills at all; no articulation. One had just grunts, one is self-mute. I immediately teach sign language and we do colors, which helps them learn very quickly. We spend a bit more time in large group, which is singing and learning through songs and movement, which also helps them." Teacher 7, a community based teacher with a moderate CLASS score and high student growth as measured by the COR-Advantage also gave some examples of how she differentiates instruction throughout the day. At the sand table, Teacher 7 said, "We're playing in the sand table and showing them what an A looks like." At snack time, Teacher 7 said, "When we eat an apple at snack, what does apple start with? A, so it's not just standing up there and singing the alphabet, but it's modeling throughout the entire day as to what that is, what it looks like, what else it could be. That kind of stuff." A different example of differentiated instruction was shared by Teacher 5. Teacher 5 said, "I think. I try really hard to spend at least a little one-on-one time with each one of them (students)." Teacher 5 continues, "I do a lot of books in the classroom, where we make books as a class and then we put them out together, so they can read them. So, we may spend a whole week on the same book, but each child is different and it takes some more time to understand." Similarly, Teacher 2 spoke at great length about differentiating her activities focused on reading. Her example was about Three Billy Goats Gruff. She said, "There are so many aspects of that. The children did dramatic play to build comprehension. We pulled out a bridge. They reenacted the story and they took turns doing that. Making bridges with materials, how can you make a bridge?"

Engagement was another strategy shared by a couple of the teachers. Teacher 2 said, "Also, when it comes to their interest, it's making sure that lessons, learning, activities and materials in the classroom are things that they're interested in so that they will engage when it's time to." Teacher 2 continues, "For example in the music and movement, how do you want to move? Or I always ask the children, it's their choice on the way that they want to move to maybe go wash their hands. They may not want to go wash their hands, but if they have the choice to make it creative, they will be more engaged and willing to." Teacher 2 also shared how she differentiates in Math and Science. She said, "And then when the grass seed grows, tying that to Math, it's Science, but tying it to Math, measurement. And then they can cut it. And then in a week, it's going to be longer and what do you predict what's going to happen?"

A different strategy that was incorporated by the preschool teachers was that of using open-ended questions. Teacher 6 said, "Instead of giving them closed end questions you're giving them open ended questions so that helps spur their creativity and imagination." Teacher 1 went into great detail about differentiating instruction when she discussed fiction and non-fiction books. She said, "We'll stay now with non-fiction and fiction for the remainder of the year. Which, you asked how we differentiate and how the teacher...that's intentional teaching. Everything I do has more than one objective." Teacher 1 continued, "Yes, I introduced non-fiction, but I also gave them a comparison of what fiction is to non-fiction, how we turn the pages; fine motor, how we look at it, the index."

Discussion

The purpose of this study was to determine the working theory about the connection of teaching and learning among UPK teachers based on their pattern of observed classroom quality and growth in child outcomes. Overall, seven preschool teachers from a large urban school district in New York State were interviewed. Semi-structured interviews were conducted to illicit preschool teacher thoughts about student learning during the preschool year. The results from this qualitative study suggest that participants believed developing relationships with families, relationships with families, differentiating instruction, and focusing on the social-emotional development of preschool children are critical in ensuring they make positive growth during the preschool year which in turn can lead to a greater opportunity to successfully transition to kindergarten.

Social-Emotional Development

Throughout the course of the academic year, preschool teachers are offered a wide variety of professional development offerings focused on social-emotional growth and development (Infurna et al., 2016). In recent years, the Rochester community has adopted the Pyramid Model as a means for providing professional support to classroom teachers (Hemmeter et al., 2014). The Pyramid Model consists of three phases of implementation, broken down into three modules. Most recently, teachers in the Rochester community were able to participate in all three phases of the Pyramid Model. It was observed that student social-emotional growth as observed by their classroom teachers grew more than that of their peers in which their classroom teacher did not participate in all three phases of training (Infurna et al., 2016).

Previous empirical studies have focused on the effectiveness of clear policies for responding to children with challenging behaviors, as well as evidence-based practices that reduce challenging behaviors in preschool children (Snyder, Hemmeter, & Fox, 2015; Sutherland, Conroy, Vo, & Ladwig, 2014; Kretlow & Bartholomew, 2010). In order to gain the essential response skills, teachers learn developmentally appropriate practices (DAP) and effective response strategies through professional development sessions. In the Rochester community, DAP over the recent years have been focused on enhancing the social-emotional development of children in pre-k programming (Infurna et al., 2018; 2016). The implementation of professional learning opportunities in Rochester has provided evidence that classroom teachers are incorporating practices learned from the Pyramid Model, which is reflected in student social-emotional growth measured throughout the course of the academic year (Infurna et al., 2016). Short-term training, often knowledge or technique based, is the most common form of in-service training with substantial various in nature and quality, with virtually no evidence of effectiveness (Birman, Desimone, Porter, and Garet, 2000). It is encouraged that the Rochester community continue to offer professional learning opportunities that not only meet the needs of the classroom staff, but also offer on-going professional learning opportunities that will assist classroom teachers in providing welcoming and nurturing environments for their children that will stimulate cognitive growth and social-emotional wellbeing.

Establish Relationships with Families

A critical component to ensuring the success of the children in your classroom is to ensure a quality relationship with the family of the child as well (Infurna et al., 2018). The classroom teachers interviewed for this study spoke at length about the importance of developing quality relationships with the families of the children in their classroom. The preschool time offered to children is both critical and important in establishing routines and enhancing the development of skills, however bridging learning to the home environment is just as critical (Nitecki, 2015). As a shift to more formalized preschool offerings are provided to families across the country, meaningful relationships between families and schools begin to take shape (Nitecki, 2015; Downer & Meyers, 2010).

Teachers that participated in this study made great lengths in bridging the gap with learning both in the classroom and at home by developing meaningful relationships with families. Parental involvement early on in their child's educational journey has been linked to greater success for the child in the elementary setting (Jeynes, 2014). Similarly, the goal of achieving meaningful family involvement in the preschool setting has been challenging, but the teachers that participated in this study were able to break down potential barriers that could have negatively impacted the development of the teacher-family relationship (McNeal, 2014). One way in which teachers developed meaningful relationships was by taking an interest in learning more about the families' culture. As stated by one teacher, they took it upon themselves to take formal college courses in another language in order to better be able to communicate with family members when visiting their classroom or when the teacher needed to communicate with the family member during home visits and phone calls. It will be important for center and program directors to allow their teachers such opportunities as a willingness for their teachers to take formal courses to better be able to communicate with and enhance their relationship with their families.

Taken as a whole, research suggests that students have greater opportunities for success in school settings when their families are involved in the educational process (Nitecki, 2015). Epstein (2010) has suggested that a new conception of a family's role in the development of their child has evolved from previously limited parental involvement within the school setting, to one now more focused on a comprehensive model of family involvement, even within preschool aged settings. It is critical for classroom teachers to bridge this gap by offering families more opportunities and involvement in the educational development of their families. Evidence from this study suggests that teachers be open, welcoming, and willing to go above and beyond to ensure their families are offered many opportunities throughout the course of the school year to be a part of their children's educational development within the classroom setting (Epstein, 2010).

Foster and Nurture Relationships with Students

The quality of relationship that forms between a teacher and their students is key to fostering and nurturing both successful instruction and learning in the classroom (Newberry, 2010). Teachers that participated in this study understood that in order to see student growth in a pre-k classroom over the course of the academic year was to get to know their students, meet their unique needs, and create an environment conducive to quality learning and engagement. The way in which the teachers in this study engaged with their students to foster quality relationships is supported by other empirical work. Reeve (2006) found that four characteristics are required to be possessed by teachers in order to aid in their quest to enhance their relationships with their students. Those traits are, a) being in tune with what might be occurring in their lives, b) being able to relate to their students, c) a sense of supportiveness, and d) classroom management.

The current empirical literature suggests that the relationship between a teacher and their students has a remarkable effect on student achievement in the classroom and in other areas of their lives (Pianta & Stuhlman, 2004). Reeve (2006) has suggested that teachers that exhibit and demonstrate more support within their classroom are better able to engage their students. In the preschool setting, those interactions can be measured by CLASS.

Shortly after the publication of the CLASS (Pianta et al., 2008), early childhood educators, policy makers, directors, and administrators in the Rochester community made the collaborative decision to begin a gradual implementation of the CLASS (Infurna et al., 2016). A primary interest of the community was to better be able to gauge teacher-child interactions in the classroom. Having already established the ECERS as a tool to monitor program quality specific to materials, physical conditions, and input from families (Montes et al., 2017), the CLASS would serve to better monitor classroom quality observed to better be able to serve the cognitive development of preschool age students in the Rochester community.

Pianta and colleagues (2008) reported that the instructional support domain of the CLASS was developed to monitor teacher-child interactions in the classroom. Previous studies have reported evidence of high classroom quality permeating from within the Rochester community (Infurna et al., 2018; Montes et al., 2017). The teachers that participated in this study had relatively high CLASS outcomes (see Table 1) compared to national averages (Infurna et al., 2016). The teachers in this study suggested that getting to know their students was beneficial and helpful with regards to helping students learn, grow, and develop in their classrooms (Reeve, 2006). Similarly, the emotional responses between teacher and student are critical in enhancing the teacher-child relationship in the classroom. Newberry and Davis (2008) suggested that the emotional responses between teachers and students also sets forth a pattern of either positive or negative interactions in the classroom. As measured by the emotional support domain of the CLASS, the teachers that participated in this study clearly have mastered the emotional component required for positive cognitive growth of children in a pre-k classroom (Infurna et al., 2018; 2016).

Differentiate Instruction to Meet the Needs of Children

The majority of preschool teachers that participated in this study spent a great deal of time discussing how they differentiate their instruction throughout the course of the school day. They spoke at great length about their attention to detail and thoughtfulness when preparing activities that would meet the specific needs of their children. Purcell and Rosemary (2008) argue that effective planning, which takes into consideration the unique needs of young children, is critically important to facilitate growth in young children. It is interesting to note that the teachers whose students grew the most throughout the course of the school year based on the COR (HighScope, 2014) and had very high CLASS (Infurna et al., 2016) scores (see Table 1) spent the more time-sharing detailed examples of how they differentiate their instruction. The classroom teachers in this study are offered a plentiful amount of professional development opportunities focused on differentiated instruction and meeting the needs of their children. Despite those opportunities for professional learning, it is evident by the student growth exhibited in these classrooms that children received similar instruction over the course of the academic year (Vlachou & Fyssa, 2016). The teachers gave specific examples about their instruction and meeting the specific needs of their students. Students did not make as many gains over the course of the school year in classrooms in which the preschool teacher did not give specific examples of how they differentiated their instruction. They spoke about the need to meet their children where they are, but they did not follow-up with examples about how they do so.

Although limited, early childhood education research and the implementation of differentiated instruction has provided positive results (Strogilos, Avramidis, Voulagka, & Tragoulia, 2018). Recently, work conducted by Gettinger and Stoiber (2012) found that classroom teachers that incorporated differentiated instruction strategies in preschool classrooms found evidence of higher performance on early literacy assessments compared to students in classrooms in which differentiated instruction was not part of the curriculum. In Head Start classrooms, the promotion of early academic skills within the differentiated instruction framework found that high-risk preschool students made significant gains on their early vocabulary assessments compared to their peers that did have the differentiated instruction model implemented in their classroom (De Baryshe, Gorecki, & Mishima-Young, 2009). Similarly, in our study, Teacher 5, Teacher 1, and Teacher 2 gave very specific examples about how they differentiate instruction in their classroom. The remaining four teachers did not give as many detailed examples specifically about how they differentiate their instruction. The potential positive link between student outcomes and classroom quality may come down to how well preschool teachers are able to articulate what they exactly do in the classroom to meet the unique and specific needs of their children.

It is also interesting to note that professional development opportunities were discussed by some of the preschool teachers that participated in this study. The school district in which the preschool students are educated spends a great amount of time and resources providing professional learning opportunities for preschool teachers. Professional development offerings are provided each month over the course of the academic year. Some of the types of professional offerings included are focused on classroom quality (specific to the CLASS), language and literacy, the HighScope (2014) curriculum, and Math. Research conducted by Catlett (2009) and Fukkink and Lont (2007) reported that professional learning opportunities for teachers are most successful when; (1) is intensive and on-going, (2) includes a sequence of active learning experiences that build on each other, (3) emphasizes specific skills and goals rather than general ones, (4) provides opportunities for application and practice of newly acquired knowledge and skills, and (5) incorporates feedback as well as reflection and self-assessment. Similarly, Catlett (2009) reported that successful professional development programs provide teachers with recommendations for research-based practices that encourage teachers to set their own goals and engagement in self-reflection throughout the process. Providing teachers with instructional resources that are useful and accessible increase the likelihood of sustainability and fidelity to the professional development approach. Although research suggests that focused professional learning opportunities for teachers are critical, teachers participating in this study are not mandated to attend any specific offerings. Rather, New York State

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mandates that preschool teachers participate in at least 24 hours of professional learning opportunities throughout the course of the academic year (NYSED, 2020). However, New York State does not mandate what types of offerings teachers are required to participate in. When asked what types of support their administration provided, only a few teachers discussed professional learning opportunities.

Again, similar to providing specific examples about differentiating instruction, Teacher 1 and Teacher 5 went into great detail about how professional development has helped them become more effective preschool teachers. Teacher 1 said, "Yes, it's always available. I have a goal of my own every year for what I'm trying to bring to a different higher level. One year it was working with children of trauma. Anything I could take." She continued, "Then another year it was more about working at this (preschool) academic level; what should it look like? What should it feel like? What should my role be?" Teacher 5 added, "We've had a lot of trainings. A lot of our trainings are on that social-emotional piece. At first I was skeptical, but then I'm like, you know what, let me just try it. And I tried it and it really...the last few years, it's really made a huge difference in the classroom." Teacher 3, whose students grew a great deal during the course of the academic year, took professional development in a different direction. Teacher 3 said, "I've been in this district a very long time, so years ago, we had a system set up that was for professional development where we met with colleagues in a very confidential basis." She continued, "You could actually share ideas, share challenges, share in a very non-judgmental format, and you learned a ton of actually strategies from your peers. I think that the collegial support setting was the most important." The other teachers referenced professional development, but they didn't give specific examples of how the professional learning assisted them in their instruction.

Conclusion

The results from this qualitative study are promising for a few important reasons. First, a majority of the preschool teacher participants expressed the importance of developing and fostering positive relationships with the families of the children in their classroom. Suggestions for practitioners would be to continue to incorporate the four traits of teacher-child relationship enhancement suggested by Reeve (2006) that would give teachers research-based prompts to enhance their relationships with their students. Preschool teachers understand the relationship between families and teachers is critical and vital in ensuring the success of children, but failed to mention any support they receive on how to develop and foster those relationships. Future research should focus on the relationship between teachers and families and how that relationship may affect the cognitive and social-emotional outcomes of their children in the classroom.

Second, only a few of the participants discussed detailed thoughts about professional learning opportunities and how they are able to apply what they learned to their daily instruction. It is encouraging to note that teachers in which their students grew a great deal throughout the course of the academic year shared specific professional learning opportunities. It is encouraged that preschool teachers attend and participate in professional learning opportunities focused on student cognitive and social-emotional development and growth. More specifically, educators should plan on attending professional learning opportunities that build upon each other, scaffold development, and are offered sequentially throughout the course of the academic year (Catlett, 2009; Fukkink & Lont 2007). Future research should be focused on the relationship between professional development, classroom quality, and student outcomes. It would be interesting to investigate the relationship between the quantity of professional development hours/trainings and classroom quality and student outcomes. Teachers in this school district are able to choose professional development offerings at their leisure, however it would be interesting to investigate how specific trainings/offerings presented in sequential order may affect classroom quality at the preschool level.

Finally, all of the participants in this study made some reference to the importance of the social-emotional development of their children during the academic year. References to social-emotional development came in accordance with developing positive relationships with the children in their classroom. However, detailed responses of social-emotional learning were given by only a few participants. Practitioners in the field of early childhood education would benefit from infusing applications shared within the Pyramid Model and developmentally appropriate practices associated with children that may be experiencing trauma in the classroom (Snyder, Hemmeter, & Fox, 2015; Hemmeter et al., 2014). It would be interesting to investigate preschool teacher perceived self-efficacy and the potential relationship with social-emotional growth of preschool children before they transition to kindergarten.

Limitations

This research study did have some limitations. First, only one male teacher volunteered to participate in this study. Throughout the early childhood education field, male teachers are seldom found in these settings.

Future qualitative studies should try to incorporate the voice of the male early childhood teacher. They (the male teacher) may be able to share their thoughts on early childhood education from a perspective that differs from a female early childhood educator. Second, only teachers employed by and working within one large urban school district participated in this study. Future qualitative preschool studies should incorporate the voice of teachers employed by rural and suburban school districts.

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Shared Reading Implementation During the Literacy Period of a Child with Hearing Loss

H. Pelin Karasu*

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*Correspondance Details: H. Pelin Karasu.
Anadolu University, Faculty of Education,
Department of Special Education, Eskisehir, Turkey.
E-mail: hpkarasu@anadolu.edu.tr
ORCID: http://orcid.org/0000-0002-9612-9858

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Abstract

Shared reading, which enables children to acquire new experiences in the field of language, is one of several fundamental instructional practices that facilitate the development of literacy skills in children from an early age. This descriptive and holistic case study aims to investigate the shared reading practices carried out in the Primary 1st Grade literacy studies. The subject of the study is a child with hearing loss who receives auditory-oral education. The data in this study have been collected through the syllabus, classroom observations, documents, the records of the validity and reliability committee, process products and the researcher's log. In the analysis of the data, the educational program and the process products have been examined, observation sessions of shared reading practices have been documented, and prominent findings have been identified. It could be safely claimed, per the findings of this study, that the features of the storybook, the literacy strategies applied during shared reading practices, and the follow-up activities contribute significantly to the benefits of shared reading practices.

Keywords:
Child With Hearing Loss, Teacher-Child İnteraction, Shared Reading, Reading Strategy, Cochlear İmplant

Introduction

Teaching literacy is a long-term process consisting of instructional practices aiming at the analysis of the reciprocity between phonemes and graphemes, and the structuring of the meaning of a text. This is mainly because the development of literacy skills in children starts well before formal education in literacy and extends over the years. (Miller, 2005). Children develop an awareness about the transmissibility of thoughts through writing by establishing a connection between spoken and written language in the pre-school period. During this period, their vocabulary expands rapidly. They start recognizing symbols, and they attend to the phonemes and graphemes they see around them. Thus, the child already has a significant understanding of the phonemes of the language at the beginning of formal reading education. With instructional practices the child starts integrating this knowledge with printed letters, and establishing a letter-sound relationship (Justice, 2006). The success of formal reading education is directly linked to the experiences acquired in the pre-school period. Therefore, it is necessary that the child is exposed to instructional practices that reinforce the development of language skills, help to understand and interpret events, and facilitate establishing relationships before formal reading education and during the first reading education (Druten-Frietman, Strating, Denessen, & Verhoeven, 2016). Shared reading (SR), as one of these practices, contributes to the development of listening comprehension, use of the language input in a variety of contexts, and the structuring of meaning (Hudson & Test, 2011). This study investigates the SR practices carried out with a child with hearing loss at Primary 1st Grade.

SR is an interactive story reading practice in which the teacher reads a text to the students either individually or in small groups, and the students participate as listeners and actively talk about what they listen to (Hudson & Test, 2011). In the literature, practices in which an adult reads a story to a child is referred to by a variety of names such as shared reading, interactive reading and dialogic reading. Some sources contend that these activities serve the same purposes and there are just minor differences among them (Blachowicz & Fisher, 2007). Dialogic reading is carried out in a way that enables the adult to ask the child questions about the target vocabulary while the adult and the child share the book. Similarly, in interactive reading, an adult reads a story to a child and asks questions while the target vocabulary is accentuated via the pictures in the story (Trussell, 2018). Terms such as "read alouds," "repeated storybook reading," "story-based lesson" and "literacy-based lesson" are frequently used in the literature on SR (Hudson & Test, 2011). In SR, the teacher reads the story aloud, guides the children to make sense of what they listen to, and points out to the structure, the sequence and the relationships among the events in the story by asking questions. New vocabulary is automatically used in the natural flow of this practice (Lederberg, Miller, Easterbrooks, & McDonald-Connor, 2014; Zucker, Justice, Piasta, & Kaderavek, 2010).

SR is one of the fundamental instructional practices that ensure interaction, scaffolding and acquisition of new experiences concerning the language. SR practices have four essential features: (a) storybooks are read multiple times at intervals, (b) the children are encouraged to take part in the activity, retell the stroy that they have listened to, and make predictions, (c) the teacher asks questions, shares the answers with the students, provides feedback to students' responses and acts as a model for the use of language, and (d) the content of the book is in line with the children's needs in terms of language, knowledge and experiences. These features enable the students to understand the structure of written texts, improve listening comprehension, develop phonetic awareness and expand their vocabulary (Druten-Frietman, et al., 2016; Lonigan, Purpura, Wilson, Walker, & Clancy-Menchetti, 2013; Strasser, Larrain, & Lissi, 2013). The comprehension of the story by a child with hearing loss depends on the features of the story and the instructional strategies that the teacher employs in SR. Instructional strategies such as using predictable texts to retell the story, showing through pictures, expanding opportunities to participate, establishing relationships, and making inferences improve children's sight-word knowledge and increase their awareness of reading fluency (Falk, Di Perri, Howerton-Fox, & Jezik & 2020).

Follow-up activities are practices that facilitate retention and reinforcement of the knowledge and experience shared with the child while offering the child the opportunity to make attempts to use the language. Crafts, dramatisation, task cards and freewriting activities can be used as immediate follow-up activities after SR. Some studies highlight the contribution of SR practices to the development of print awareness (e.g. Spencer, Goldstein, & Kaminski, 2012; Evans, & Saint-Aubin, 2013). The adult's and the child's focus, and verbal or visual direction of the child's attention to print during SR are important for the development of print knowledge (Piasta, Justice, McGinty, & Kaderavek, 2012). A variety of techniques can be employed to direct and intensify the child's attention to print in SR practices. These techniques may take verbal or non-verbal forms. For instance, the child's attention can be verbally directed to print by talking about what is written in the story or, nonverbally, the child can be shown the print while reading. Piasta et al. (2012), in their longitudinal study with 4-year-olds, have applied SR for thirty weeks and directed the children's attention to print both verbally and nonverbally. In the two years that followed, a significant improvement was observed in the word reading and comprehension skills of the children whose attention was directed to print.

Majority of the literature on the application of SR practices on children with hearing loss in the school environment has been carried out in the pre-school period, with some of the studies focusing on the children's participation (Williams & McLean, 1997; Gioia, 2001), and vocabulary teaching (Trussell, & Easterbrooks, 2014), while others on the strategies employed and early literacy skills (e.g. DesJardin et al., 2014; Werfel, Lund, & Schuele, 2015). Williams and McLean (1997) studied the participation of kindergarten students in SR group practices and observed that the participation patterns in these activities were similar for children with and without hearing loss and that SR increases the participation of children with hearing loss. Similarly, a study by Gioia (2001) demonstrates that children with hearing loss manage to retell the story and participate more and more in the activity in each subsequent lesson provided that their active participation is ensured and also that the materials are chosen in accordance with their recipient and expressive language skills. Furthermore, Trussel and Easterbrooks (2014) studied the effect of SR practices on vocabulary learning of children who use the sign language and studied the effect of SR practices on vocabulary learning of children who use the sign language and concluded that these practices facilitate vocabulary learning. Desjardin et al. (2014) investigated the strategies that adults used during SR and found out that adults who work with children with hearing loss used the strategies of labelling, showing through pictures, improving participation, expecting predictions, and summarizing more frequently than their counterparts who work with hearing children. This was explained to be an indication of the higher intensity of the language skills needs of children with hearing loss compared to their hearing peers. Werfel et al. (2015) compared the early literacy skills of children with hearing loss to those of their hearing peers and found no significant difference in terms of the alphabetical knowledge but observed a latency on behalf of the children with hearing loss in the print and vocabulary knowledge. All researchers agree that SR practices support the children with hearing loss in the areas that they have difficulty in, and underline the need to apply these activities in a systematic and organised way.

Presently, there is only one study in Turkey that has investigated SR practices on children with hearing loss. In the above mentioned study, Girgin (2013) investigated the SR practices applied to children with hearing loss in the Primary 1st Grade auditory-oral education and determined the strategies used. Findings of the study point out that multiple readings and use of reading strategies support the structuring of meaning and help children adopt these strategies. No other study that focuses on the time allocated to shared reading practices, the stages of the practices, and the use of writing experiences in the follow-up activities has been carried out with children with hearing loss in an educational environment in which the auditory-oral approach is applied.

SR facilitates the development of oral language skills of children with hearing loss in educational environments where the auditory-oral appraoch is applied. SR activities make it possible for the children to listen to a story read aloud by an adult, to talk about the events in the story, and to ask and answer questions (Girgin, 2013). Moreover, these activities provide opportunities for children to expand their vocabulary range and establish relationships between thoughts, events and print. Thanks to these benefits, SR is considered among the best practices and evidence-based practices that have an important role in special education. Another reason for this is the fact that the contribution of SR to the improvement of language and academic skills of children has been documented through both quantitative (experimental, quasiexperimental, single subject, correlation researches) and qualitative research (Hudson & Test, 2011).

The recent advances in the field of hearing aids technology and cochlear implants have aroused expectations that children with hearing loss can acquire listening and speaking skills on their own like their hearing counterparts. However, the benefits of these developments concerning hearing aids depend largely on early diagnosis, early education and the quality of the educational environment. In addition to the qualities that enable the child with hearing loss to understand a story that he listens to, the requirements that will allow him to benefit from SR practices in an educational environment where the auditory-oral approach is applied will be demonstrated as an outcome of this study. It is believed that the findings of this study will guide the teachers who work with children with hearing loss in SR practices, draw attention to the significance of SR, and contribute to the literature in the feld. This study aims to investigate SR practices carried out in the Primary 1st Grade literacy lessons. Accordingly, it aims to answer questions such as (1) how the storybooks were designed in SR practices, (2) how SR was implemented, and (3) how the SR practices were integrated to writing experiences.

Method

A descriptive and holistic single case design model has been used in this study to investigate the SR implementation process. In a descriptive case study, it is imperative that a phenomenon is clearly described and conceptualised. Such case study models require outlining the phenomenon in question in the first place. This study also involves a detailed analysis of the SR practices as a whole. In this respect, this study is a holistic single-case design. (Yin, 2009).

Educational Environment

The study was carried out in the Education and Research Center for Hearing Impaired Children (ICEM), founded in 1979 as part of Anadolu University. ICEM is a research and application center which offers children with hearing loss full-time day education based on the auditory-oral approach at the preschool, primary, and middle school levels as well as early provision of hearing aids and tracing their audiological development. At ICEM, the children receive three years of pre-school education, in addition to 4 years of primary and 4 years of middle school education.

Besides, IÇEM offers reverse inclusion programs in pre-school education so that children with hearing loss attend school with their hearing peers in natural and structured environments to improve their academic and social skills. At primary and middle school levels, the children are enrolled in the state school next to the center for inclusion and are given support education services by ICEM. Literacy studies are based on the whole language approach in the pre-scool period and the balanced literacy approach at the primary school level.

Participants

During the course of this study, there were 8 children with hearing loss at the Primary 1st Grade in the 2014-2015 academic year. The study focused on a child who was diagnosed with hearing loss (at the age of 34 months) and started using a hearing aid (at the age 35 months) at what is considered to be a late age. He started pre-school when he was 52 months old without ever receiving early intervention programmes (pseudonym Tan). The underlying reason for the choice of this subject is the interest in how a child with hearing loss who was introduced to auditory input late in his life would participate in the SR practices in an educational environment in which the auditory-oral approach was used. Tan, who recevied two years of pre-school education at ICEM before primary school, is 6 years 4 months old and he underwent a cochlear implant operation when he was 40 months old. His average hearing loss in the left ear is 98 dBHL. His parents are primary school graduates; the mother does not work and the father is a seasonal worker. Tan has a brother who is three years older and has no hearing loss. In the Primary 1st Grade, group lessons and one-on-one sessions are carried out by two teachers who have studied Teaching Children with Hearing Loss. One of the teachers have 20, and the other one has 14 years of practical experience in working with children with hearing loss. The researcher has been working on the improvement and assessment of the literacy skills of children with hearing loss for 24 years.

Data Sources and Procedures

As part of a longitudinal approach, this study focuses on the SR practices carried out in the Primary 1st Grade in the 2014-2015 academic year. Data collection techniques applied in the study include the curriculum and the instruction programs, in-class observations, documents, records of the validity and reliability committee meetings, process-products and the researcher's log. The Turkish Course program planned in accordance with the Social Studies Course in the Primary 1st Grade, the storybooks chosen for the SR practices and the modifications on these books, participation of the child in these practices as a group member and the process-products including task cards and freewriting texts have also been taken into consideration.

Data Analysis Process

The analysis of the qualitative data is inductive in nature. Detailed data sets constitute general categories (Creswell, 2005). Accordingly, storybooks used in SR practices were analyzed, classroom observations of the practices were documented and prominent traits have been highlighted after a thorough examination of the process-products. Four themes have emerged as a result of this process: (a) the design of the storybook, (b) reading of the story and retelling it, (c) direction of story telling and question answer sessions, and (d) the writing experience.

Trustworthiness and Validity

To ensure credibility in the study, a variety of data collection techniques were employed, the research process was monitored, collection and analysis of the data were carried out systematically, the extensive amount of data collected was verified by a validity and reliability committee. Two experts were involved in the validity process and 6 validity meetings were held in the 2014-2015 academic year.

Ethics

Informed consent of Tan's family, teachers and the research center was obtained for this study, which is part of a longitudinal study in which SR practices in Primary 1st Grade were investigated.

Results

Prominent Traits Have Been Documented Below

How were the storybooks designed in the SR practices?

The subjects in the curriculum, dates of implementation and the names of the storybooks used in SR practices are presented in Table 1.

As seen in Table 1, a total of 36 storybooks were read in class as one story for each weekly topic in the curriculum. Every week, other than the four-day ones that coincided with the holidays on the Republic Day and the New Year, consisted of five school days on which the same story was read. Specifics of the design of the storybooks used in SR have been given below.

The stylistic features of the book not only make it easier for the reader to understand but also increases the motivation to read (Machado, 2007). On the cover of the books, are pictures depicting the main

Table 1
Subjects in the Curriculum, Dates of Implementation, and the Names of the Story

Subject	Date	Story Book
Holiday	15-19 September 2014	Cemile Learns to Swim
Our school	22 September-03 October 2014	Cemile Goes to School Atakan Starts School
The City That We Live In	06-17 October 2014	Gülenay and the Little Duck Yasemin in the Patisserie
Our Home and Family	20-24 October 2014	Atakan Stays with his Grandma
The Republic Day	27-31 October 2014	Long Live the Republic
Vehicles	03-14 November 2014	Gülenay and the Little Puppy Gülenay and the Little Pony
Autumn	17-21 November 2014	Atakan Goes to the Playground
Cleanliness	24 November -05 December 2014	Cemile Wears her New Boots Sleepyhead Kimi
Winter	08-12 December 2014	Kimi Who Doesn't Like Bathing
Balance	15-26 December 2014	Curious Kimi Ayben at the Circus
The Calendar and the New Year	29 December 2014-02 January 2015	The Christmas Tree
What Do We Wear And When	05-23 January 2015	Gamze and her Nephew Kimi on the Way to School
Hot-Cold	09-13 February 2015	Gamze at her New House
Natural Disasters	16-20 February 2015	Snowstorm
Traffic and Safety	23 February -06 March 2015	Gamze and her New Dog Hande and her Dog on the Train
Solid-Liquid	09-13 March 2015	Yasemin and her Little Visitor
Animals we Eat	16-27 March 2015	Gamze by the Lake Yasemin and Karbeyaz
Wool-Leather-Silk	30 March -03 April 2015	Elif at the Farm
Spring	06-17 April 2015	Gamze and her Kite Gamze in the Garden
April 23rd Children's Day	20-24 April 2015	Cemile Loves her Friend Dearly
Shopping	27 April -08 May 2015	Elif Cooks Pizza Atakan Goes to the Supermarket
Plants around Us	11-22 May 2015	Yasemin at the Camp Gülenay out for a trip to the Countryside
Youth and Sports Day	25-29 May 2015	Yasemin in the Balloon Fest
National Days	01-05 June 2015	Cemile Won't Share her Toys
Summer	08-12 June 2015	Cemile Goes on a Holiday

characters and events in the stories in addition to the names of the books. There are also colorful and clear illustrations in the books about the events in the story. Features of these books concerning the structuring of meaning have been categorized as per (a) propriety for the curriculum, (b) relationships between events, (c) relationships between the story and the illustrations and (d) readability of the text.

(a) Propriety for the curriculum. The themes of the stories to be used in SR practices need to be appropriate for the age, language skills and knowledge experience of the children. Choosing books that the children can relate to using their own experience plays an important role in their structuring of the meaning of the events (Girgin, 2013; Miller, 2005). It was observed in this study that the themes in the storybooks displayed a certain congruency with the curriculum that equips the children with new information and experience. The vocabulary used in the Social Studies Course was also used in meaningful contexts repeatedly (Clark, 2007). For instance, in the weeks between the 5th and the 23rd of January 2015, the chapter covered in the Social Studies lesson was titled "What do we wear and when?" In the first one of the two weeks allocated for this chapter, the story read in the class was "Gamze and her Nephew" and in the second week, it was "Kimi on the Way to School." The story titled "Gamze and her Nephew" is about Gamze's nephew who comes to visit her during the winter break, how they wear winter clothes to play snowball and have fun with their friends. This SR practice enabled children to share the language and the construct of the story, apply their knowledge and experience and use such words as 'scarf,' 'cap,' 'coat,' 'jacket,' 'gloves' and 'boots,' which were used in the Social Studies lessons, in meaningful contexts (Schirmer, 2000).

(b) Relationships between the events. The sequence of events in the story must follow an order that fits in with the storyline and the illustrations must support the relationship between the events (Gerek, Karasu & Girgin, 2019). Therefore, the stories used in the practice have been modified, pages that disrupted the flow or unity of the story were taken out and the sequence and relationships of the events were restored.

(c) Relationships between the story and the illustrations. There needs to be an explicit connection between the text and the illustrations in the stories used in SR practices so that the children can use and share the visual clues when they have difficulty in listening comprehension (Girgin, 2013; Machado, 2007). Therefore, while modifying the storybooks, it was ensured that the text and the illustration on the same page matched one another. For instance, on the second page of the story "Gülenay Out for a Trip to the Countryside", read between the 11th and the 22nd of May, 2015, Gülenay can be seen picking mushrooms and putting them in her hat, while her dog barks at a tortoise. And the text on the same page reads: "We should not crush the mushrooms. Let's pick the big ones first. There you go. I don't want anything to happen to my new hat." To establish the connection between the text and the illustration, a subscript was inserted into the illustration, which read, "Gülenay came to the countryside with her dog. She picked mushrooms. She put them into her hat. Her dog barked at the tortoise."

(d) Readability of the text. Children's understanding of the read-aloud depends on such features of the text as the theme, the children's experiences concerning the theme and the events in the story, vocabulary range, sentence structure, the length of sentences and the variety of vocabulary items (Karasu, Girgin & Uzuner, 2013; Moody, 2006). Accordingly, the readability of the texts used in this study has been adjusted before SR to the language and knowledge level of Tan. As Tan's language skills improved, the level of difficulty of the language used in the stories was also observed to increase gradually in the academic year during this process. For instance, in the picture on the first page of the story "Cemile Learns to Swim" read between the 15th and the 19th of September, 2014 as part of the chapter titled "Holiday", Cemile and her parents are seen at the seaside with other people sitting on the beach. The original text on the page and the modified text can be seen below.

Sample 1.
The original text on the page:
"Great! We are going to the seaside," shouted, Cemile. She was about to go to the beach with her parents. They had spent the previous day by the seaside, too. They had enjoyed the sea, the sun and the warm sands.

Modified text:
Cemile and her parents came to the seaside during the holiday.

In the picture on the second page of the story "Yasemin at the Baloon Fest" which was read towards the end of the academic year, as part of the chapter titled "Youth and Sports Day" between the 25th and the 29th of May 2015, it is seen that some children are holding balloons, Yasemin and her friends are releasing their balloons and the balloons are flying away. The original text on the page and the modified text is given in Sample 2 below.

Sample 2.
The original text on the page:
It was an exciting day for all the children. Everyone gathered in the football pitch behind Yasemin's house. Yasemin could not miss this assembly. Each child had a flying balloon. They tied a label with their names and adresses to the balloons. Yasemin tied the label with her name and address to her balloon, as well. She said, "You have a nice trip," and released the balloon. Balloons in all colors started ascending towards the sky. Children returned to their homes in anticipation. They all wondered who would find their balloon.

Modified Text:
Yasemin and Gizmo went to the park. Children were holding balloons of various colors. They all released the balloons. They were very excited.

A seen in Samples 1 and 2, the text in the book consisted of complex and compound sentences, adjective and noun clauses and abstract nouns. Therefore, the text was reduced and abstract concepts were replaced for Tan to understand what he listened to. The modified text of the story used at the beginning of the term (Sample 1) can be seen to consist of a single sentence and contain nouns that Tan used frequently. The modified text of the story used towards the end of the term (Sample 2), however, consists of four sentences. These are sentences with a verb as a predicate and, in the sentence, there are adjectives and adverbs associated with the nouns and the verb. Based on this change, Tan can be said to have shown improvement in his listening comprehension skills through the academic year.

How was SR implemented?

Stages of implementation for every page in SR are presented below as (1) reading of the story and the child's retelling it (2) direction of narration and question-answer strategy.

1. Reading of the story and the child's retelling it

Reading starts with showing the cover page of the book to the child. The teacher points out to the name of the book, reads it aloud and dwells on the meaning of the name. The teacher then asks questions about the characters and the events depicted on the cover page and asks Tan to predict the events in the story. After talking about the cover page, the teacher reads the first page of the book, asks Tan what he has understood and prompts him to retell what he has understood. When Tan fails to retell the story, the teachers reads the text on the same page again.

Episodes 1 and 2 display the stages of the activity concerning the story titled "Autumn," read between the 17th and the 21st of November, 2014.

> *Episode 1.*
> *Teacher shows the cover of the book and says, "Today, you and I are going to read a story. The name of the book is Atakan Goes to the Playground," and points at the name of the book on the cover page. The teacher asks, "So what is the name of the book?" Tan replies, "Atakan Goes to the Playground." The teacher asks "Who is Atakan?" Tan, pointing at the picture on the cover of the book replies, "Atakan is name of child." The teacher points at the picture on the cover page of the book and asks "Who does Atakan go to the playground with?" Tan says, "His dog goes." The teacher responds by saying, "Yes, Atakan goes to the playground with his dog," and thus expands Tan's reply... While opening the first page, the teacher says, "Now, I am going to read. Listen carefully." Without showing the picture, the teacher reads the sentence, "Atakan, his mother and Çomar go to the playground. Atakan holds his mother's hand." Asking the question "What do you make of this?" the teacher makes Tan tell her what he understands. Tan fails to respond. So the teacher says, "Listen carefully. I am going to read it once again," and reads the text on the page again and asks "What happened?" Tan says, "His dog goes to the playground." The teacher asks "What then?" and wants Tan to go on narrating the story....*

As seen in Episode 1, the teacher expands Tan's replies and encourages him to keep telling the story through promts such as "What happened later?" and "Think about it," without offering clues.

2. Directing narration and question-answer strategy

The teacher listens to Tan's narration, acknowledges what he says, expands the response, and through questions and answers on what he has not talked about, checks his understanding, and directs the narration. After the narration, she asks questions regarding the causal relationships between the events, encourages inferencing and predicting while giving Tan time to think about his responses. If Tan's response is accurate she acknowledges his success, if not, she simplifies the structure of the quesiton and helps Tan to come up with an answer by offering clues. (Episode 2).

> *Episode 2.*
> *... The teacher asks the question "What will Atakan do in the playground?" before she moves on to the next page. Tan replies by saying, "He will play." Teacher says, "Let's see what he does," and reads the sentences on the second page: Atakan and Comar play in the sandbox. His mother sits and reads. She asks "What do you make of this?" Tan says, "Atakan is playing." The teacher asks "What does Atakan play with?" Tan cannot answer the question. Teacher shows him the picture on the page and by pointing at the sand, says, "Look at what he plays with." Tan responds by saying "He plays sand." Teacher says "Well-done," writes the word "sand" on the board and asks Tan to read it...*

As seen in Episode 2, words that Tan sees for the first time or fails to understand were written on the board, read aloud and explained, which offered him clues as to the print form of the word. It was observed that Tan tried to narrate the text with short sentences and could not answer some of the questions. Table 2 displays sample cases in which Atakan understood and answered the questions, and had difficulty in doing so during the SR practice of the story titled "Atakan Goes to the Playground."

As seen in Table 2, Tan managed to answer the questions with simple question words or which required palpable events as answers, but had difficulty understanding and answering questions which required interpreting events as a whole, estbalishing relationships and making predictions.

How were SR practices and writing activities integrated?

In order to provide writing experience after the SR practices, Tan was given task cards in the first 4 days of the week, and the last days of the weeks were devoted to freewriting as follow-up acitvities.

Task cards are leaflets on which the sentences on each page of the storybook, read aloud by the teacher, are

Table 2
Kinds of Questions Tan Understood and Answered, and Those He Had Difficulty Doing so

Questions Tan Understood and Answered		Questions Tan had Difficulty Answering	
Question	Sample	Question	Sample
What	What is Atakan doing?	with whom/what	What is Atakan playing with?
Who	Who is in the park?	why	Why is Atakan playing alone?
Where	Where are the children?	when	When are the kids going home?
Why	Why did Atakan go to the park?	from whom/where how	Where are the kids coming from? How did the kids build the tower?

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Table 3

Number of Task Cards and Number of Words Used in FreeWriting

Date	Story Book	Follow-up Activity		
		Task Card (Day/Number)	FreeWriting	
			TNW*	TWC*
15-19 September 2014	Cemile Learns to Swim	First 4 days/10	1	-
22 September-03 October 2014	Cemile Goes to School Atakan Starts School	First 4 days/10 First 4 days/11	1 2	--
06-17 October 2014	Gülenay and the Little Duck Yasemin in the Patisserie	First 4 days/10 First 4 days/11	2 2	1 1
20-24 October 2014	Atakan Stays with his Grandma	First 4 days/12	2	1
27-31 October 2014	Long Live the Republic	First 3 days/10	NA	NA
03-14 November 2014	Gülenay and the Little Puppy Gülenay and the Little Pony	First 4 days/10 First 4 days/10	2 3	1 1
17-21 November 2014	Atakan Goes to the Park	First 4 days/12	3	1
24 November -05 December 2014	Cemile Wears her New Boots Sleepyhead Kimi	First 4 days/12 First 4 days/11	2 2	1 1
08-12 December 2014	Kimi Who Doesn't Like Bathing	First 4 days/11	3	1
15-26 December 2014	Curious Kimi Ayben at the Circus	First 4 days/12 First 4 days/12	3 NA	2 NA
29 December 2014-02 January 2015	The Christmas Tree	First 3 days/10	3	2
05-23 January 2015	Gamze and her Nephew Kimi on the Way to School	First 4 days/12 First 4 days/11	3 4	2 2
09-13 February 2015	Gamze at her New House	First 4 days/12	4	2
16-20 February 2015	Snowstorm	First 4 days/12	3	3
23 February -06 March 2015	Gamze and her New Dog Hande and her Dog on the Train	First 4 days/1 First 4 days/13	NA 4	NA 2
09-13 March 2015	Yasemin and her Little Visitor	First 4 days/13	4	3
16-27 March 2015	Gamze by the Lake Yasemin and Karbeyaz	First 4 days/13 First 4 days/14	5 3	2 2
30 March-03 April 2015	Elif at the Farm	First 4 days/13	4	4
06-17 April 2015	Gamze and her Kite Gamze in the Garden	First 4 days/14 First 4 days/14	4 NA	3 NA
20-24 April 2015	Cemile Loves her Friend Dearly	First 4 days/14	5	3
27 April-08 May 2015	Elif Cooks Pizza Atakan Goes to the Supermarket	First 4 days/14 First 4 days/14	4 5	3 4
11-22 May 2015	Yasemin at the Camp Gülenay out for a trip to the Countryside	First 4 days/14 First 4 days/12	7 5	5 4
25-29 May 2015	Yasemin in the Balloon Fest	First 4 days/14	4	4
01-05 June 2015	Cemile Won't Share her Toys	First 4 days/14	5	4
08-12 June 2015	Cemile Goes on a Holiday	First 4 days/14	NA	NA
11-22 May 2015	Yasemin at the Camp Gülenay out for a trip to the Countryside	First 4 days/14 First 4 days/12	7 5	5 4
25-29 May 2015	Yasemin in the Balloon Fest	First 4 days/14	4	4
01-05 June 2015	Cemile Won't Share her Toys	First 4 days/14	5	4
08-12 June 2015	Cemile Goes on a Holiday	First 4 days/14	NA	NA

**TNW=Total Number of Words, TWC=Total Number of Words Written Correctly, NA= Not Available*

written. Tan was asked to read the sentences on these task cards, write them down in his own notebook and draw a picture of the events in the sentences. In instances when he failed to read, the teacher pointed out to the first letter of the word to offer a clue, and after reading the sentence, asked Tan "What happened?" to check his understanding one more time. Tan, then wrote the sentence in his notebook, drew the picture and the teacher checked his understanding for the last time. When it was finished, Tan wrote the date on the back of the task card he studied on and moved on to the next task card. The task cards were thus completed after story reading in four days. Tan was not given a task card on the 5th day and was given a freewriting task. In freewriting tasks, the teacher showed him the book and asked him which event he wanted to write about, expecting Tan to pick one of the events in the book. Tan drew a picture of the event of his own choice and wrote sentences about what happened under the picture. He was not offered any visual clues during this writing activity. Table 3 shows the number of task cards used in the follow-up activities and the number of words Tan used to describe the picture in his freewriting efforts.

Task cards prepared with regard to the story

The number of cards depends on the events in the story and the number of pages read on a specific day. The average number of cards concerning a story ranges between 10 and 14 (Table 3). On top of each card is the name of the story–written in red, and below are one or two sentences about one of the events in the story–written in black. The font size was 14 and Vertical Basic Alphabet letters were used. A quick look at the features of the task cards that help structuring meaning will reveal that (a) the sentences read aloud by the teacher and listened to by the child are written on the task cards, (b) the sentences are about palpable events that yield to illustrations, and that (c) similar to the text of the story, the level of difficulty of the language used in the task cards gradually increases as the language skills of the child improves. For instance, the third page and the relevant task card of the story titled "Cemile Goes to School" read as part of the chapter "Our School" between the 22nd of September and the 3rd of October, 2014, reads "Cemile's mother held her hand. They went to school together." The task card concerning the fifth page of the story titled "Atakan Goes to the Supermarket" read as part of the chapter on "Shopping" betwen the 26th of April and the 8th of May, 2015, reads "Atakan went to the toys stand. His mother was not with him. Atakan was lost. The security officer approached him."

Writing Related Experience

It can be observed through features of freewriting concerning the structuring of meaning that (a) the child draws a picture of en event of his choice and writes his remarks under this picture, (b) the freewriting products go through a revision process where the child and the teacher interact on a one-on-one basis, and (c) revised, corrected and filed writing products are read out in one-on-one sessions involving the child and the teacher. During the study, on the days other than those Tan didn't show up for school, a total of 31 freewriting products have been obtained (Table 3). In these activities, Tan tried to write a single word as the name of the character in the story at the beginning of the semester and the number of words and the ones he wrote correctly increased towards the end of the semester. The sentences, however, turned out to be the same as the ones he wrote on the task cards in the first 4 days of the week. For instance, after listening to the story titled "Yasemin at the Camp" read as part of the chapter on "The Plants around Us" towards the end of the semester between the 11th and the 15th of May, 2015, for 5 days and doing the task cards activities, Tan wanted to write about the events on a page which reads "Yasemin, her mother, father, Pınar and Gizmo went out to the garden. They looked at the squirrels in the tree." He wrote six of the words in the sentence correctly (Yasemin, her mother, father, Pınar, Gizmo), and two words contain errors. One of them has an incorrect word spelling (garden), the other has a tense error (went out). The words he wrote correctly are the names of the characters in the story that have been repeated frequently. The same sentence was also written on one of the task cards about the story.

Discussion

Optimization of the benefits of SR depends on the features of the materials to be used in the practices, and the instructional strategies employed to meet the child's needs. It can be observed in this study that the themes in the storybooks used in SR practices matched the subject matter of the Social Studies course; that the same story was modified and read multiple times during the week; that a variety of instructional strategies were used and follow-up activities were employed to offer writing experiences. An empirical study conducted with children with hearing loss at pre-school level (Pataki, Metz, & Pakulski, 2014) concludes that storybooks which are parallel in terms of theme with the subject matter covered in class facilitate interaction and participation in SR practices. The similarity between the theme in the storybook and the subject covered in class also enables practice and repetition of new vocabulary and sentence structures in a variety of contexts (Girgin, 2013; Otaiba, 2004).

Children are exposed to natural opportunities to learn new vocabulary in their daily lives. Children with hearing loss, however, cannot benefit from these natural opportunities due to their limited vocabulary and need various modifications and a lot of repetition of language structures to ensure the development of their vocabulary range (Clark, 2007). The parallelism between the themes of the stories used in SR practices and the content of the Social Stuides course, the multiple readings of the story, and the integrated use of reading and writing skills in the follow-up activities contribute to the lexical and syntactic development of children with hearing loss who use spoken language (Strasser et al., 2013). Multiple readings also enable these children to recognize, use and control reading strategies, and internalize the features of written language by reinforcing the improvemnet of higher cognitive skills (Stewart, Bonkowski, & Bennet, 1990).

This study was conducted in the Primary 1st Grade where decoding skills are taught formally. In Turkey, the Phonic Based Sentence Method (PBSM) is used to equip children with these decoding skills. The first literacy program prepared by the Ministry of National Education (MoNE) also recommends listening activities in addition to PBSM. Children with hearing loss who have latency in their language skills usually have difficulty in the listening comprehension of these materials prepared for their hearing peers. Therefore, instead of the listening scripts in the MEB course books, modified storybooks were used in this study.

Both stylistic features of the materials used in SR practices and their features regarding the structuring of meaning play significant roles in children's understanding of the story they listen to. The same page illustration of the events in the text, the sequence of illustrations to demonstrate the relationship between these events, and the appropriety of the readability level of the text to the language skills of the child all facilitate listening comprehension and structuring of meaning. This kind of reading materials also increases motivation which has a prominent role in the structuring of meaning (Machado, 2007). The language in the storybooks used in this study has been modified to match the language skills of the child with hearing loss so as to assist the development of the child's skills in listening comprehension and structuring meaning.

Another determinant in the success of SR practices is the way these practices are carried out. Kaderavek and Justice (2002) point our that it is necessary to (a) enable children to share their thoughts and feelings concerning the events in the story, (b) encourage participation, (c) reinforce the development of linguistic skills, and (d) increase the children's interest in the books while carrying out SR practices. During this study, the teacher read the story to the child and then asked the child to retell the story. The child's retelling the story not only facilitates listening comprehension skills but also enables the assessment of these skills (Machado, 2007). Retelling the story was followed by the direction of the narration, expansion of the child's response, sharing the events in the story through questions and answers, inviting the child to talk about his thoughts and feelings about the story, correction of mistakes and encouraging praticipation. Throughout the implementation of these strategies, Tan tried to retell the story, answered some simple questions and had diffciulty in understanding and answering some others. His failure to answer certain questions may be due to the reason that he didn't understand the question, that he didn't know how to respond to the question or that he didn't know the answer. By implication, supporting the development of listening, comprehension and speaking skills make the use of reading strategies easier and these strategies in turn facilitate the development og language skills (Schirmer, 2000).

It is pointed out in other researches investigating SR practices (Williams, & McLean, 1997; Gioia, 2001) that the teacher's attitude and the strategies applied during implementation affect the child's participation, and extra attention needs to be paid to these two issues to increase active participation and motivation. Directing narration, furthering child's participation, supporting the development of lingusitic skills, asking questions and sharing answers have a positive impact on the motivation of the child with hearing loss. Use of these strategies facilitate oral participation skills of the child and improves vocabulary range, morpho-syntactic skills and comprehension skills (DesJardin et al., 2014; Kaderavek & Justice, 2002).

SR practices consist of instructional practices that support the literacy skills of children with hearing loss who experience latency in their language skills through 'natural environments' and 'natural forms of interaction' during intervention programs (Kaderavek & Justice, 2002). SR not only facilitates the achievement of language and literacy targets but also creates opportunities to implement strategies to improve these skills in children with hearing loss. Vocabulary range, for instance, is an important factor in the development of literacy skills. In this study, new vocabulary items for Tan were accentuated in their natural context and their meaning and written form were demonstrated. Sharing new vocabulary items in meaningful contexts for the children in this way makes their use and retension easier (Akay, 2015; Trussell & Easterbrooks, 2014).

Literacy experiences are directly related to the establishment of the letter-sound relationship of the language, and the development of syntactic, semantic and pragmatic skills (Schirmer, 2000). A follow-up activity is the kind of post-lesson exercise that offers experiences related to the language and literacy and enables the use of the language used in the classroom in a variety of contexts. Follow-up activities after SR need to support the child in the integration of reading and writing skills using the language and information obtained from the story that the child listens to (Pakulski & Kadarevek, 2004). Existing literature on SR predominantly focuses on the pre-school period, and therefore, does not relate to writing activities. In this study, which was conducted in the Primary 1st Grade, task cards were used systematically in the first four days in the follow-up activities and Tan was asked to read and rewrite what is written in the cards and picture the events. The last school day was devoted to freewriting sessions aiming at the integration of his writing skills with his listening, speaking and comprehension skills. Task cards and the writing activities carried out on the last day of the week at school played an important role in the structuring of meaning, and the integration of listening, speaking, reading and writing skills (Girgin, 2013).

An examination of the task cards used throughout the Primary 1st Grade in this study will reveal that sentence structures have gradually become more complex, and the number and variety of words have increased towards the end of the term. These sentences, as specimens of the language used in the shared stories, can also be observed in the writing products of the last day of the week. Findings show that, in the first few months, Tan wrote only a couple of words in the freewriting activities and these words were usually misspelt. This might suggest that the development of desired skills took a slow start. However, this was probably due to the gradually increasing complexity of the shared stories, the child's inexperience in expressing events in writing, and his need to practice. The writing products that Tan has come up with after SR practices towards the end of the academic year display characteristics of 'invented writing.' In the invented writing stage, children manage to write some words that they frequently see and make attempts at establishing letter-sound relationships while writing the words disregarding any formal rules (Hofslundsengen, Gustafsson & Hagtvet, 2019). In this study, Tan had difficulty coining a sentence expressing his thoughts on the event he wanted to write about and tried to remember and use the words written on the task cards. This is why writing products do not display the characteristics of 'conventional writing.' In his attempts at writing, Tan tried to use his alphabetic knowledge in writing activities and tried to write down certain words that he recalled by bringing letters together. Writing process products obtained towards the end of the semester can therefore be considered as evidence of increasing motivation to write and development of print knowledge (Piasta & Wagner, 2010).

Limitations and Recommendations

This study was carried out in an educational environment in which early intervention principles were applied within the framework of the auditory-oral approach. The subject of the study was a child with hearing loss who has been attending SR practices since the pre-school period and is currently in the Primary 1st Grade. The data collected is restricted to a time span of one year. The benefits to be obtained from SR practices in the educational environment depend largely on the implementation, assessment and utilization of the features of the materials, instructional strategies and follow-up activities with an eye towards the language and knowledge levels of the child as well as the modification of these so as to fit in with the child's needs. Therefore, it is important to assess the child's vocabulary range and skills in listening, retelling, establishing relationships, predicting, and understanding and answering questions in the educational environment. The implementation process has to be closely monitored. The language used in the readings, the variety of questions, and the follow-up activities have to be continuously re-designed to match the improvement in these skills. It can be suggested for future studies to look into the contribution of SR practices to literacy skills through longitudinal studies, and assess the impact of SR practices on writing products through qualitative and quantitative studies.

Conclusion

Although cochlear implants alleviate the latency in language skills, a child with hearing loss still has difficulty developing language skills in certain aspects and needs support to structure meaning. SR practices are known to play a significant role in overcoming these challenges. Based on the findings of this research, it can be safely claimed that (a) the modifications on the storybooks, (b) the instructional strategies used and (c) the follow-up activities that offer writing experience are important factors in reaping full benefits of SR practices.

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Two Years vs. One: The Relationship Between Dosage of Programming and Kindergarten Readiness

Charles J. Infurna[*,a], Guillermo Montes[b]

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[*,a]**Correspondance Details:** Charles J. Infurna. Children's Institute, Department of Clinical and Social Sciences in Psychology, University of Rochester, USA.
E-mail: cinfurna@childrensinstitute.net
ORCID: http://orcid.org/0000-0001-9960-440X

[b]Guillermo Montes. St. John Fisher College, Ralph C. Wilson, Jr. School of Education, Rochester, USA.
E-mail: gmontes@childrensinstitute.net
ORCID: http://orcid.org/0000-0002-7980-6044

Abstract

This research study investigated the effects of preschool dosage on kindergarten readiness in an urban school district (*n*= 1,464). This study was guided by one research question: do children who attend two years of structured early childhood education programming (3-year- old and 4-year-old pre-k) demonstrate stronger academic skills than their peers who only attend one year of pre-k programming (4-year-old pre-k only)? Implementing univariate and multivariate logistic regression models, we found that children who attend two years of programming were 34% more likely to make a successful transition to kindergarten compared to their peers who only attended pre-k as 4-year-olds. Black students who attended two years experienced a greater benefit, with a 53% increased likelihood of being kindergarten-ready.

Keywords:
Dosage of Programming, Early Childhood Education, Preschool, Student Outcomes

Introduction

Public funding for early childhood education (ECE) for 3- and 4-year-old children in the United States has seen an increased amount of spending and resources provided for the enhancement of programming over the past decade (Friedman-Krauss et al., 2018). Previous research has shown that children attending high-quality early learning programs can improve school readiness in transitioning to kindergarten (Duncan & Magnuson, 2013; Yoshikawa et al., 2013). Recent proposals from the state level have initiated efforts to expand ECE to allow more children to enroll in full-day programming before transitioning to kindergarten (New York State Education Department [NYSED], 2020). These initiatives aim to serve not just more children but also younger children, addressing a need to provide quality ECE programming to children at-risk and those living in poverty (Jenkins et al., 2016). This expansion includes individual state increases in programming for 3- and 4-year-olds provided at the district level. The primary goal of these public preschool expansions is to ensure that more children living in poverty have access to high-quality ECE programming (Bassok et al., 2016).

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Many states, such as New York, provide some school districts grant funding above $1 million to support full-day ECE programming for 3- and 4-year-old children (NYSED, 2020). The expansion of programming has provided more school districts in New York State the opportunity to expose young children to earlier forms of structured programming before the start of the kindergarten year (NYSED, 2020). Recently increased state funding has thus resulted in a greater number of children enrolled in ECE programming at an earlier age than in previous years (Ansari et al., 2019). Nationally, fewer than 20% of children under the age of 2 are enrolled in some type of ECE programming (National Survey of Early Care and Education Project Team, 2015). However, as children age, so does the percentage of enrollment. For example, approximately 35% of three-year-old children and 60% of 4-year-olds are enrolled in some type of early childhood programming across the country (Ansari et al., 2019). With state increases in funding, there is a growing need to further understand the effect that early educational programming exposure has on children before transitioning to kindergarten (Ansari et al., 2019), and whether any benefits persist and can be detected over time.

The objective of this study is to answer one key question: Are children who attend two years of programming better prepared to make a successful transition to kindergarten compared to their peers who only attend one year of pre-k programming? We use data collected from an ongoing longitudinal study serving an urban school district located in New York State (Infurna, Riter, & Schultz, 2018) to compare student academic and developmental outcomes before they transition to school-aged kindergarten programming within the same school district. Three- and 4-year-old students who are enrolled in programming are served both by the school district and Community Based Organizations (CBO), such as Head Start and the School districts that offer full-day programming for both 3- and 4-year-old children are required to house at least 10% of children enrolled in programming in CBO's that will funnel children to the school district when entering kindergarten (NYSED, 2020).

This study extends prior findings from previous dosage studies in several ways. First, it compares the academic outcomes of three groups of children. One group of children did not have contact with early pre-kindergarten (EPK) programming. A second group of children were enrolled in EPK but had chronic attendance issues (NYSED, 2020). The third group of children had regular EPK attendance and also had matching fall/spring assessment outcomes.

The current study is similar to that conducted by Jenkins et al. (2016) in which Head Start students in the state of Oklahoma were compared based on whether children attended one or two years of programming at the Head Start and school-based level. This study also extends the recent work conducted by Ansari et al. (2019) in which they investigated the academic, social-emotional, and executive functioning of children. In their study, Ansari et al. (2019) hypothesized that children who attended a 3-year-old programming would have stronger academic skills at the 4-year-old entry compared to their peers who did not attend a 3-year-old programming. Ansari et al. (2019) reported that students who attended 3-year-old programming outperformed their peers at school entry the following year in math, language, and literacy achievement. Unlike Jenkins et al. (2016) and Ansari et al. (2019), participants of this study were drawn from an urban school district located in New York State (Infurna et al., 2018). As such, this study is designed to make a rigorous statistical comparison between three groups of children in a sample consisting of children who had no contact with EPK, those with some contact with EPK, and students who attended a full year of EPK before transitioning to kindergarten in an urban school district in New York State.

Background

ECE Programming in New York State

New York State has seen a gradual rise of full-day 4-year-old ECE programming over the past decade (NYSED, 2020). School districts across New York can apply for grant funding that, in turn, would create more 4-year-old programming opportunities for children who otherwise would not be able to afford to attend full-day programming before the kindergarten year. As recent as the 2015–2016 academic year, New York State began offering school districts the opportunity to apply for grants that would create full-day programming for 3-year-old children (early pre-kindergarten; EPK). This development provided school districts with even greater opportunities to enroll more children in full-day pre-kindergarten programming who otherwise would not have been able to attend or enroll.

Head Start programs across New York State have offered full-day and half-day programming options for children for decades. However, not all children have access to programming due to a limited number of enrollment slots and locations. The opportunity for school districts to apply for ear-marked grant funding has allowed a greater proportion of children living in poverty to have access to full-day high-quality programming beginning at age 3. Since the inception of full-day 3-year-old funding, only approximately 70 of the over 600 school districts in New York State have been awarded funding (NYSED, 2020).

ECE Program Quality in New York State

It is unclear how to gauge the success of 3- and 4-year-old programming with regard to successful readiness to transition to kindergarten in New York State. School districts that receive EPK and/or universal pre-kindergarten (UPK) full-day funding are offered a wide variety of curricula and classroom assessment tools for implementation (NYSED, 2020). As of completion of this study, New York State had not released EPK or UPK student outcome data, either at the school district level or as a state in the aggregate.

As part of the New York State EPK and UPK grant mandates, school districts are required to select a cognitive, social-emotional, and classroom quality-assessment tool. A majority of 3- and 4-year-old programs across the nation implement the Child Observation Record—Advantage (COR—Advantage) tool developed by HighScope (2014). The school district in which data were utilized for this study has implemented a version of the COR for over two decades (Infurna et al., 2018). Another popular student assessment tool that is offered to school districts in New York State includes the Woodcock-Johnson III (Woodcock et al., 2001). Two additional commonly-used classroom instruments that are offered to school districts, again that are mandated as part of receiving full-day EPK and UPK funding, are the Classroom Assessment Scoring System (CLASS) (Pianta et al., 2008) and the Early Childhood Environment Rating Scale-3rd Edition (ECERS-3) (Harms et al., 2015). The CLASS observation tool measures the quality of interactions observed between the classroom teacher and students (Pianta et al., 2008; Infurna et al., 2018). The ECERS-3 observation tool also measures the quality of interactions between students and teachers, but includes items focused on measuring the quality of the physical environment in which the children are enrolled (Harms et al., 2015; Infurna et al., 2018). Similar to student cognitive outcome data, classroom quality outcomes are not reported by most of the participating EPK and UPK programs. One such school district annually produces a report that documents student outcomes and classroom quality observed in EPK and UPK programming (Infurna et al., 2018). Otherwise, the degree of the quality of preschool programming in New York State, either in the aggregate level or by school district, is unknown to the research team.

Comparing Student Achievement by Dosage Effect

The influence of program duration on student academic and social-emotional outcomes is essential to understand whether two years of programming is more beneficial than one year of programming to students before transitioning to kindergarten (Jenkins et al., 2016). Approximately 50% of Head Start children who enroll in a 3-year-old programming will also be enrolled as 4-year-olds for an additional year of programming before transitioning to kindergarten (Tarullo et al., 2010). The empirical evidence suggests that the more time spent in ECE programming before transitioning to kindergarten, the stronger the cognitive outcomes in children, compared to their peers with less time spent in center-based ECE programming (Dearing et al., 2009).

The evidence also suggests, however, that the impact of attending the first year of programming is generally greater in magnitude than that of the second year of attendance (Tarullo et al., 2013). Similarly, another intensive early-learning programming, such as the Perry Preschool Project, produced significant positive effects (Schweinhart, 2005) and other preschool programs produced substantial positive effects with only one year of program attendance (Gormley et al., 2005). Most recently, Jenkins et al. (2016) reported that no statistically significant differences could be detected between children who attended two years of Head Start programming and their peers who only attended Head Start programming as 4-year-olds. The purpose of this research study was to determine if attending two years of preschool programming was more beneficial than one year for children living in an urban school district in Western New York State.

Method

Research Design and Analysis

We posed the following research question: Do children who attend two years of structured ECE programming (3-year-old and 4-year-old pre-k) demonstrate stronger academic skills than their peers who only attend one year of pre-k programming (4-year-old pre-k only)?

We hypothesize that children who attend two years of programming will demonstrate stronger academic gains at the end of the pre-k year and be more ready to successfully transition to kindergarten than their peers who only attend one year of programming.

Data

Participants

Secondary data analysis was conducted focused on 3- and 4-year-old children enrolled in full-day programming through an urban school district in New York State. Upon receiving approval from the Western Internal Review Board (WIRB), data were used from the 2018-19 academic school year. The data collected from this ongoing longitudinal study come from multiple sources: direct cognitive assessments of children at the beginning (fall) and end of the school year (spring) conducted by the classroom teacher and administrative data collected by the school district and surrounding CBOs. Our research question focused primarily on children who had participated in a 3-year-old programming for the duration of the 2017–2018 academic year and who were also enrolled in a 4-year-old programming during the 2018–2019 school year, and on 4-year-old children who were enrolled in programming during the 2018–2019 school year. One group of children did not have contact with early pre-kindergarten (EPK) programming. A second group of children was enrolled in EPK but had chronic attendance issues (NYSED, 2020). The third group of children had regular EPK attendance and also had matching fall/spring assessment outcomes.

Table 1

Number and Age of Students by Group

Age	N	M*	SD
No EPK	888	53.49	3.54
Partial EPK	335	54.03	3.38
Full EPK	241	53.89	3.17

*Note: *Age in months.*

Table 1 shows the number and average ages of participants in each of the three groups. As can be seen, the students were of similar ages. Out of the sample of 1,464 students, 61% had no contact with EPK. 39% of the sample of students had some contact with EPK. Of those, 58% attended partially and 42% completed the EPK program. Group one children had no EPK contact. Group two children had partial EPK contact (chronically absent; NYSED, 2020). The third group of children had matching fall/spring COR-Advantage data and were considered high-attenders (NYSED, 2020).

Measures

Child academic data were collected at three points in time during the academic year (November, March, June), which included all eight categories of the COR-Advantage (HighScope, 2014). Classroom teachers observed children throughout the day, wrote anecdotes of their observations, and provided a child developmentally-appropriate score of 1–7 on 35 different items that make up eight categories (Approaches to Learning, Social-Emotional Development, Physical Development & Health, Language, Literacy, & Communication, Math, Creative Arts, Science and Technology, and Social Studies) (HighScope, 2014). The authors of the COR-Advantage established a kindergarten-readiness criterion in their latest development instrument (HighScope, 2014). A child is considered kindergarten ready if they score >= 3.75 on each category and have an overall COR-Advantage score >= 4.0 (HighScope, 2014). The overall COR-Advantage score is derived from adding the scores of the eight categories and then dividing by eight.

Analysis

The sample was inspected using frequencies and cross-tabulations. Univariate logistic regression models were estimated to determine the likelihood of kindergarten readiness by group. Multivariate logistic models were estimated to control for student age, gender, and race/ethnicity. Finally, these multivariate logistic models were re-estimated for separate ethnic/racial groups. The statistical significance was set at $p < .05$.

Results

Table 2 displays the demographics of the sample, showing a similar distribution by gender across the three groups. Regarding race and ethnicity, 7% of White students in UPK had completed EPK, compared to 15% of Hispanic students and 19% of Black students. Partial attendance had a similar demographic pattern, with 14% of White students, 22% Hispanic students, and 25% of Black students. Students who were identified as other race/ethnicity mirrored the pattern of Black students in this sample.

Table 2

Demographics of the Sample

	No EPK		Partial EPK		Full EPK	
	N	%	N	%	N	%
Male*	437	49.21	182	54.33	117	48.55
White non-Hispanic	118	79.73	20	13.51	10	6.76
Hispanic	271	63.17	93	21.68	65	15.15
Black non-Hispanic	448	56.07	200	25.03	151	18.90
Other race/ethnicity	51	57.95	22	25.00	15	17.05

*Note: * remaining students are female*

Table 3 shows the univariate and multivariate logistic regression models. In all cases, kindergarten readiness was the dependent variable. Univariate results showed that students who had attended EPK were 34% more likely to be kindergarten ready by the end of UPK than students who had not attended EPK (OR 1.34, $p < .05$). Although the odds ratio for the comparison between students who had partially attended EPK versus those who had not attended at all was smaller by 6%, it was no longer statistically significant (OR 1.28, $p > .05$).

In the largest multivariate logistic analysis, we controlled for the student's age, gender, and race/ethnicity. This multivariate analysis confirmed the univariate results for the comparison of full EPK versus no EPK, estimating a 37% increased likelihood of kindergarten readiness. Once controls are added to the model, the 6% differential between partial and full EPK remains, but is now statistically significant (OR 1.31, $p < .05$).

Table 3

Logistic Models on Kindergarten Readiness at the end of UPK

	Partial EPK vs. No EPK		Full EPK vs. No EPK	
	OR	95% CI	OR	95% CI
Univariate model	1.28	(0.99–1.65)	1.34*	(1.01–1.79)
Multivariate model	1.31*	(1.01–1.69)	1.37*	(1.02–1.84)
Restricted to White students	0.47	(0.18–1.26)	1.11	(0.27–4.61)
Restricted to Hispanic students	1.04	(0.64–1.68)	1.27	(0.73–2.20)
Restricted to Black students	1.70*	(1.20–2.39)	1.53*	(1.05–2.24)

In addition, we estimated multivariate logistic regression models for racial/ethnic subgroups of students. These results show that the effect size was higher for Black students with a 53% increased likelihood to be kindergarten ready by the end of the UPK year, and a 70% chance for those who attended EPK partially.

Because the majority of the students in the study sample were Black, the analyses restricted to White and Hispanic students are probably underpowered. However, small sample sizes do not influence the effect size, which is quite different from the univariate overall results. Hispanic students who attended full EPK had an effect size of 1.27, while White students had a smaller effect size of 1.11. The results for partial EPK attendees were weaker with only a 4% increased likelihood for Hispanic students and a negative effect size for White students. Again, these differences were non-significant, which is likely the result of the small sample size.

Discussion

Conclusions

The purpose of this research study was to determine if two years of preschool programming better prepared children than one year of preschool to make a successful transition to kindergarten. Our sample consisted of three groups of children; a) no contact with EPK programming, b) partial EPK contact, and c) full year EPK contact who were enrolled in both school-based and community-based programming within the umbrella of an urban school district. The current study adds to the existing body of empirical literature on the dosage effects of early preschool entry for children and the effect of early entry on cognitive development before making the transition to kindergarten, as defined by school readiness (HighScope, 2014).

This study provides evidence that in an urban school setting, EPK attendance may boost kindergarten readiness at the end of the UPK year. The effect is moderate, with our best estimate being a 37% increased likelihood of kindergarten readiness. As expected, partial EPK attendance had a weaker effect by about 6%. We also provide weaker evidence that these results may differ for various ethnic or racial groups. These results mirror those presented by Karoly et al. (2015), which reported that more time spent in structured ECE programming resulted in stronger developmental gains. Our results also support those reported by Loeb et al. (2004), which suggest that earlier entry and prolonged duration of programming yielded greater cognitive gains for children entering programming at 2.5 years of age while remaining enrolled through age 4. This was in comparison to peers who either did not attend programming at all (similar to a group of children in this study) or who entered at a later age. Our findings also support those reported by Puma et al. (2012) that students enrolled in Head Start programming at age 3 made greater language gains than their peers who enrolled as 4-year-olds.

Zaslow et al. (2010) reported that stronger developmental outcomes were associated with more hours of ECE attendance. However, our study did not focus on time as defined by hours of attendance, but rather how many days a child attended (NYSED, 2020) and whether attendance resulted in matching fall/spring cognitive-developmental outcome data.

In 2007, Loeb et al. found that Black preschool students benefitted more from full-day programming than did their peers. Our outcomes for Black students support those reported by Loeb et al. (2007). In our case, we found stronger partial attendance effects for Black students, while there were non-significant effects for White and Hispanic students. Even if the results had been significant for these two subpopulations, the effects of EPK were estimated to be substantially weaker — 27% for Hispanic students and 11% for White students. Partial attendance effects were even weaker. Thus, EPK attendance had a powerful association with kindergarten readiness at the end of the UPK year in our sample, which may have been concentrated in a particular subgroup of students.

Limitations of the Study

None of the groups were randomized and, thus, the groups are nonequivalent in both measured

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and unmeasured characteristics. Attribution of the increased likelihood of the EPK attendance needs to be confirmed by future randomized studies. Our measure of kindergarten readiness relied exclusively on the form of assessment (teacher-completed COR-Advantage) and the results may be different using other measures of kindergarten readiness. Finally, the results of this study may not be generalizable outside of the particular urban school district studied, as other EPK programs may differ in substantial ways from the one that was studied here. The analysis for White and Hispanic students may have been underpowered, but as mentioned above, low statistical power should not influence effect size.

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Investigating Reading Literacy in PISA 2018 Assessment

İlhan Koyuncu[*,a], Tahsin Fırat[b]

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[*,a]**Correspondance Details:** İlhan Koyuncu. Adiyaman University, Department of Educational Sciences, Adıyaman, Turkey.
E-mail: ilhankync@gmail.com
ORCID: http://orcid.org/0000-0002-0009-5279

[b]Tahsin Fırat. Adiyaman University, Department of Special Education, Adıyaman, Turkey.
E-mail: tahsinfirat02@gmail.com
ORCID: http://orcid.org/0000-0002-3577-7907

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Abstract

This study aims to investigate the predictors of reading performance and how reading performance predicts mathematics and science performances in PISA 2018 study. For this purpose, the country in the focus (Turkey), the highest performer (China [B-S-J-Z]) in the world, and the lowest performer (Mexico) among the OECD members countries were selected as the research sample. A total of 12058 students participated from China (Male=6283, Female=5775), 6890 students from Turkey (Male=3494, Female=3396), and 7299 students from Mexico (Male=3473, Female=3826) in PISA 2018 study. The results revealed that 'Index of economic, social and cultural status', 'Meta-cognition: assess credibility', and 'Meta-cognition: summarizing' are the most significant factors affecting students' reading literacy in all three countries. Total explained variance explained is 41%, 41%, and 39% for Turkey, China (B-S-J-Z) and Mexico, respectively. 'Index highest parental occupational status', 'Duration in early childhood education and care', 'Attitude towards school: learning activities', and 'Subjective well-being: Sense of belonging to school' are not significant predictors for reading literacy of students from all three countries. In addition, regarding the predictivity of reading literacy, total variance explained is 65% in mathematics performance and approximately 77% in science performance for all three countries.

Keywords:
PISA 2018 Study, Reading Literacy, Mathematics Literacy, Science Literacy

Introduction

Education plays an important role in social development. A good education system contributes to industrial, technological, and artistic development as well. Countries seeking to be a pioneer in these fields effectuate various education policies and allocate a considerable part of their budgets to education. In that regard, countries willing to test their academic achievement at national level and to see their level of competence in international platforms participate in some assessment processes and accordingly review their systems (Berberoğlu & Kalender, 2005; Tavsancil, Yildirim, & Bilican Demir, 2019). The Program for International Student Assessment (PISA) is one of the relevant assessment processes. It measures 15-year-old students' reading, mathematics, and science literacy every three years. Each cycle focuses on one of these three major domains of study, though two other domains are also included in the assessment. The focal subject was science in 2006 and 2015, mathematics in 2003 and 2012, and reading in 2000, 2009 and 2018 (Organisation for Economic Co-operation and Development [OECD], 2019a). The fact that the reading skills are chosen as the focal subject means that PISA 2018 results focus on reading skills rather than mathematics and science literacy. This study is important in terms of revealing which factors are more effective on reading performance and its relationship with mathematics and science achievement.

Factors Affecting Reading Literacy

Reading literacy refers to understanding, evaluating, using and engaging with written text to participate in the society, to achieve one's goals and to develop one's knowledge and potential (OECD, 2019b). In this context, it can be said that reading is a difficult and complex process that requires many cognitive skills (Adams, 1990). Therefore, it is possible to say that there are many factors that affect students' acquisition of reading skills and successful display of them (Esmer & Güneş, 2019; Linnakyla, Malin, & Taube, 2004). Studies reveal that achievement in reading comprehension is affected by a variety of factors, i.e., fluent reading (Kim, Petscher, Schatschneider, & Foorman, 2010; Klauda & Guthrie, 2008), text structure information (Englert & Hiebert, 1984; Pyle et al., 2017), cognitive and metacognitive strategies knowledge (Fırat & Koçak, 2019; King, 1991; Wu, 2014), vocabulary (Elleman, Lindo, Morphy, & Compton, 2009; Nelson & Stage, 2007), motivation (Becker, McElvany, & Kortenbruck, 2010; Logan, Medford, & Hughes, 2011; Taboada, Tonks, Wigfield, & Guthrie, 2009) and previous knowledge (Kendeou & Van Den Broek, 2007; Ozuru, Dempsey, & McNamara, 2009). The factors of achievement in such a difficult and multidimensional process also involve socioeconomic and familial conditions, school type, reading habits, learning strategies, and participation in preschool education (OECD, 2019a). For example, Hemmerechts, Agirdag, and Kavadias (2017) determined that participation of parents in literacy activities in preschool education of their children, parental education status, and socioeconomic status have significant effects on students' acquisition of reading skills.

The Relationship of Reading Literacy with Mathematics and Science Performance

Students' achievement in reading is important in terms of demonstrating their skills in other academic domains. If a student's reading literacy level is low, it generally implies difficulties in the acquisition of several other skills in most cases (Geske & Ozola, 2008). In order to be successful in science and mathematics, the reader must first read and understand well the text and symbols and interpret what they read. Rindermann and Baumeister (2015) emphasized that it is very important to consider reading performance when interpreting students' achievement (including science and mathematics performance) in PISA. From PISA 2006, 2009 and 2012 data, as well as from their relevant studies with students and teachers, Akbaslı, Sahin and Yaykiran (2016) found that reading comprehension is a significant predictor of mathematics and science achievement. Fuentes (1998) argued that mathematics and reading go hand in hand; students need to improve their reading so as to increase their mathematics achievement, in other words. It is possible to come across a number of studies that reveal the relationship between reading skills and mathematics achievement (Erdem, 2016; Ding & Homer, 2020; Grimm, 2008; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2005; Osterholm, 2005).

In a longitudinal research on the covariance of the relationship between reading and mathematics achievement, for example, Grimm (2008) examined the associations between third grade reading comprehension and changes in three components of mathematics achievement (problem solving and data interpretation, mathematical concepts and estimation, mathematical computation) from third through eighth grade. Third grade reading comprehension was found to be a positive significant predictor of change for each component of mathematics. Students with a greater level of reading performance in early elementary school were found to be more rapid and successful in mathematics. Besides, reading comprehension was shown to be related to a conceptual understanding of mathematics and the application of mathematics knowledge. It is possible to come across several other studies that likewise reveal a close relationship between reading ability and science achievement (Bayat, Sekercioglu, & Bakir, 2014; Cano, García, Berbén, & Justicia, 2014; Cromley, 2009; O'Reilly & McNamara, 2007). O'Reilly and McNamara (2007) found that reading skills help the learner compensate for deficits in science knowledge for most measures of achievement. Similarly, in a study via the PISA 2000, 2003 and 2006 data, Cromley (2009) revealed that greater level of reading skill brought higher science achievement.

Importance of the Study

Studies show that a variety of factors affect reading comprehension and the latter has an effect on science and mathematics achievement. Nevertheless, there are not many studies showing how effective these factors are on reading skills. Identifying the factors that have more impact on reading skills will enable countries aiming to develop these skills to decide what to focus on or what changes they should make in their education policies and programs. We have not come across much findings in the related literature as well, regarding to what extent reading is effective on science and mathematics achievement. We therefore consider it important to determine the extent to which reading achievement affects science and mathematics achievement.

Accordingly, within the scope of this study, we analysed the assessment results of those who participated in PISA from Turkey, China (B-S-J-Z) and Mexico. Selected as a focus country, Turkey participated in the PISA test for the first time in 2003. Turkey's record of reading in PISA can be summarised as follows: In 2000, Turkey did not take part in the test in which 43 countries participated. Turkey ranked 35th out of 41 in 2003, 37th out of 57 in 2006, 41st out of 65 in 2009 and 2012, and 50th out of 72 countries in 2015. 79 countries participated in PISA 2018. In the domain of reading, Turkey ranked 40th out of 79 countries participating in PISA 2018, while ranking 31st among the 37 OECD countries. The rate of Turkish students ahead and at the second level of reading proficiency was 73.9%, which was below the OECD average. China was chosen as the second country. Regarding China's PISA history, Shanghai represented China in joining PISA for the first time in 2009. It ranked first in the PISA tests held in 2009 and 2012. In PISA 2015, the Chinese region consisting of four provinces/ cities of Beijing-Shanghai-Jiangsu-Guangdong (B-S-J-G) ranked 27th in reading. China again ranked first in reading skills in PISA 2018. Moreover, China became the only country where more than 90% of its students performed at the proficiency level 2 or above. It is seen that Mexico's PISA record is poor in all tests held since 2000. It ranked last among the OECD countries and 7th from the bottom among the countries that took the test in 2000, while it was 3th from the bottom in 2003. This trend of failure continued in 2006, 2009, 2012 and 2015 as well. In PISA 2018, it ranked 53rd in general and 36th (second from the bottom) among the OECD countries. Colombia, the most failed OECD country in the PISA 2018, was not included in the study, as it had a recent PISA record as an OECD member country in 2018. The purpose for choosing these countries is the fact that Turkey, which the researchers are from, was at moderate performance level, China (B-S-J-Z) was the best performer, and Mexico was the worst performer in terms of reading skills. Thus, it was aimed to achieve more generalizable results by comparing the possible factors affecting reading literacy in countries with different performance levels and different characteristics.

Aim of the Study

We aimed to investigate the predictors of reading performance and how reading performance predicts mathematics and science performance of Chinese (B-S-J-Z), Turkish and Mexican students in PISA 2018. For this purpose, we sought answers to the following research questions:

1. What are the statistically significant predictors of reading performance of Chinese (B-S-J-Z), Turkish and Mexican students in the PISA 2018?

2. What are the rankings of statistically significant variables in predicting reading performance of Chinese (B-S-J-Z), Turkish and Mexican students in the PISA 2018?

3. How does reading performance of Chinese (B-S-J-Z), Turkish and Mexican students predict their mathematics and science performance in the PISA 2018?

Method

The method section consists of five sub-sections including research design, participants, data collection tools, validity and reliability, and data analysis.

Research Design

This study aimed to examine the characteristics, background information, cognitive and non-cognitive outcomes in reading literacy skills of the Chinese (B-S-J-Z), Turkish and Mexican students. Since it is aimed to describe the data obtained from the student questionnaires of PISA 2018 for a specific group of students, the present study is a survey research. In addition, the relationship between background information, cognitive and non-cognitive tendencies of the students and reading, mathematics and science literacy skills was investigated in the scope of the present study. Therefore, it is also a correlational research which attempts to predict the student performance based on linear correlations between independent and dependent variables.

Participants

The target population of the PISA 2018 study is 15-year-old students attending in different type of schools at grade 7 or higher across the world. For the purpose of the present study, the highest performer (China), the country in the focus (Turkey), and the lowest performer in the OECD members countries (Mexico) were selected as the research sample. A stratified sampling method was used in PISA studies. PISA 2018 technical report (OECD, n.d.) could be examined in detail to understand the whole sampling process. A total of 12058 students participated from China

(Male=6283, Female=5775), 6890 students from Turkey (Male=3494, Female=3396), and 7299 students from Mexico (Male=3473, Female=3826) in the PISA 2018 study.

Data Collection Tools

Data used in this study were collected via student questionnaires and cognitive items developed to measure reading, science, and mathematics literacy in the PISA 2018 study. In order to measure reading skills, PISA 2018 defined various dimensions, including different types of text and cognitive processes in which the reader interacts with the text, as well as questions and tasks at different levels of difficulty. As part of the PISA 2018 reading assessment framework, there are four different cognitive processes that readers actively display while reading a text: "access to information", "interpretation", "evaluation and reflection", "fluent reading". Different text types show how the information in the text is organized (e.g. stories or explanatory texts). Within the scope of reading skills, two different types of questions were used: The questions that the student chooses from among the options (multiple choice, yes/no, true/false questions), and questions the answers of which are constructed by the student (questions with short or long answers) (OECD, 2019b).

The student questionnaire consists of items to assess a range of non-cognitive and demographic variables. In addition, 10 plausible values (PVs) were evaluated for reading, science and mathematics literacy and subscales of reading literacy. In large scale assessments (e.g. TIMMS, PISA etc.), more than one plausible value was calculated for each student from posterior distribution of ability parameters estimated with Item Response Theory (IRT) models. It is suggested in PISA manuals to use all these plausible values in analysing PISA data. Detailed information about scaling and analysing of test scores in PISA assessment were provided in PISA 2018 technical report (OECD, n.d.).

For the aim of the present study, non-cognitive and demographic variables that might affect reading literacy of students were selected for China (B-S-J-Z), Turkey and Mexico. Moreover, the variables not applied together in three countries were eliminated from the data. 21 variables that might predict students' reading performance were determined. The reason for choosing these variables arises from the fact that each of them is one of the factors affecting reading literacy or has characteristics close to these factors in the related literature (e.g. Artelt, Schiefele, & Schneider, 2001; Erdoğan & Güvendir, 2019; Geske & Ozola, 2008; Kır, 2016; Manolitsis, Georgiou, & Tziraki, 2013; Mikk, 2015; Miyamoto, Pfost, & Artelt, 2019; Perry & McConney, 2010; Rajchert, Żułtak, & Smulczyk, 2014; Sénéchal, 2006; Sénéchal & LeFevre, 2002; Soodla, Jõgi, & Kikas, 2017; Shala & Grajcevci, 2018).

Instead of using too many variables in PISA data, the researchers preferred variables consisting of a combination of more than one variable. For example, index of economic, social, and cultural status (ESCS) consists of many variables such as home and cultural possessions, number of books, parents' education and occupation, etc. Consequently, among all the variables included in the PISA 2018 student data, the possible variables determined by the researchers that can affect the reading skills are as follows:

1. *Attitude towards school: learning activities (ATTLNACT)*
2. *Subjective well-being: Sense of belonging to school (BELONG)*
3. *Teacher-directed instruction (DIRINS)*
4. *Disciplinary climate in test language lessons (DISCLIMA)*
5. *Duration in early childhood education and care (DURECEC)*
6. *Parents' emotional support perceived by student (EMOSUPS)*
7. *Index of economic, social and cultural status (ESCS)*
8. *General fear of failure (GFOFAIL)*
9. *Highest education of parents (HISCED)*
10. *Index highest parental occupational status (HISEI)*
11. *Joy/Like reading (JOYREAD)*
12. *Meta-cognition: assess credibility (METASPAM)*
13. *Meta-cognition: summarizing (METASUM)*
14. *Perceived feedback (PERFEED)*
15. *Self-concept of reading: Perception of competence (SCREADCOMP)*
16. *Self-concept of reading: Perception of difficulty (SCREADDIFF)*
17. *Teacher's stimulation of reading engagement perceived by student (STIMREAD)*
18. *Teacher support in test language lessons (TEACHSUP)*
19. *Learning time (minutes per week) - in total (TMINS)*
20. *Meta-cognition: understanding and remembering (UNDREM)*
21. *Gender (GENDER)*

Among these variables, gender was categorical and it was coded as a dummy variable in the analysis. The other variables were continuous or ordinal and hence they were included in the analysis as continuous variables.

Validity and Reliability

The results of PISA studies, which have been implemented seven times since 2000, are widely used in the evaluation of education systems all over the world. In the Technical Report and Assessment and Analytical Framework documents published after each PISA cycle, the construction of scales and construct validity, selection of the representative sample, ensuring application reliability, coding reliability, reliability of the scaling process are discussed in detail and shared as open access (see OECD, n.d.; OECD, 2019a). In the Assessment and Analytical Framework book, the structure of the scales used (reading, mathematics, science, questionnaires, etc.) is explained in detail. The Technical Report includes the construction process of scales, ensuring coding reliability, and the details of the scaling process. Therefore, PISA data which is collected for use in scientific studies as well, is a highly valid and reliable data.

Data Analysis

Multiple linear regressions were performed to predict reading performance of the students from independent variables given above. The reason for choosing this analysis method is the fact that it is the preferred method in cases where the differentiation in a dependent variable is estimated based on more than one independent variable. In this study, the predictive power of the 21 variables given in the data collection section in estimating reading performances of the students was examined. To compare statistically regression coefficients for each of independent variables across countries, the following formula suggested by Clogg, Petkova, and Haritou (1995) was used.

$$Z = \frac{\beta_1 - \beta_2}{\sqrt{(SE_{\beta_1})^2 - (SE_{\beta_2})^2}}$$

where β_1 and β_2 are standardized regression coefficients and $SE_{\beta 1}$ and $SE_{\beta 2}$ are their standard errors. Besides, Fisher's (1921) z transformation was used to compare R^2 values.

Besides, simple linear regressions were carried out to predict students' mathematics and science performance from reading literacy. Before performing the analysis, the assumptions of linear regression analysis were examined. Following results were obtained regarding the examination of the assumptions of multiple linear regression for each of plausible values:

1. There was at least one independent variable.
2. Dependent variable was continuous. Except gender, other independent variables were also continuous. Gender was dummy coded.
3. Independence of observations were satisfied.
4. There was very few residuals and extreme values (approximately 0.2% for each plausible value) that were negligible.
5. There was an approximately linear relationship between dependent and independent variables (Linearity).
6. The error in the relationship between independent and dependent variables were similar across all independent variables (Homoscedasticity).
7. There was no multicollinearity or singularity.
8. The variables were approximately normally distributed according to histograms and skewness-kurtosis values (-1, +1). The residuals have approximately standard normal distribution according to normal P-P plot and normal Q-Q plots.

10 plausible values were used as representative of reading, mathematics, and science performance of the students. Data were analysed based on PISA Data Analysis Manual (OECD, 2009). Therefore, the IEA International Database Analyzer (IDB Analyzer) was used to generate SPSS syntaxes. This software was developed by IEA Data Processing and Research Centre to analyse large-scale assessments data including PISA study. IDB Analyzer takes into account sampling design information and 10 plausible values while generating codes for the SPSS and SAS software to test hypothesis. The analysis was performed for each PV and then all results were combined as explained in PISA technical reports (see OECD, n.d.). This process that performed via SPSS syntaxes is more than just averaging all PVs. Whole syntaxes used in this study were generated via IDB Analyzer and the analyses were performed with SPSS software. 80 replications were performed for each of 10 plausible values.

Results

The results of each research question have been provided separately in the following sections.

Prediction of Reading Literacy from Selected Independent Variables

In order to determine significant variables that predict students' reading literacy, multiple linear regressions were executed for data obtained from each country. Regression coefficients (*B*), standard errors of regression coefficients [*B (s.e.)*], standardized regression coefficients (β) and t values for each variable and country are given in Table 1.

According to Table 1, 'Index of economic, social and cultural status', 'Meta-cognition: Assess credibility', 'Meta-cognition: Summarizing, 'Teacher-directed instruction', 'Disciplinary climate in test language lessons', 'Self-concept of reading: Perception of difficulty', 'Highest education of parents', 'Perceived feedback', 'Meta-cognition: Understanding and remembering', 'Teacher's stimulation of reading engagement perceived by student', 'Parents' emotional support perceived by student', 'Joy/Like reading, and 'General fear of failure' are 13 significant variables that explained 41% variance of reading literacy of Turkish students, respectively. Except the 'highest education of parents' variable, the rest of the significant variables for Turkish students are also significant for Chinese students. In addition to these variables, 'gender' and

Table 1

Multiple Linear Regression Results

	Turkey[1]				China (B-S-J-Z)[2]				Mexico[3]			
Independent Variables	*B*	*B (s. e.)*	*β*	*t*	*B*	*B (s. e.)*	*β*	*t*	*B*	*B (s. e.)*	*β*	*t*
Constant	526.47	15.65		33.65*	501.09	13.92	.	36.00*	461.00	17.11	.	26.95*
1. ESCS	26.23	3.84	0.37	6.83*	14.90	3.46	0.19	4.31*	15.22	4.08	0.23	3.73*
2. METASPAM	22.8	1.81	0.26	12.56*	23.80	1.40	0.27	17.01*	14.77	1.75	0.18	8.46*
3. METASUM	14.95	1.6	0.17	9.34*	13.17	1.29	0.15	10.22*	14.98	2.10	0.17	7.15*
4. DIRINS	-10.21	1.86	-0.12	-5.49*	-7.69	1.41	-0.09	-5.45*	-8.92	2.45	-0.11	-3.64*
5. DISCLIMA	9.91	1.66	0.11	5.98*	5.91	1.44	0.07	4.11*	8.84	2.18	0.10	4.06*
6. SCREADDIFF	-9.09	1.8	-0.10	-5.04*	-7.40	1.30	-0.08	-5.70*	-5.93	2.09	-0.07	-2.84*
7. HISCED	-4.57	1.71	-0.10	-2.67*	2.10	1.56	0.04	1.35	-2.33	2.04	-0.05	-1.14
8. PERFEED	-6.11	2.1	-0.07	-2.91*	-4.18	1.38	-0.05	-3.03*	-9.73	1.76	-0.12	-5.51*
9. UNDREM	6.21	1.75	0.07	3.54*	8.82	1.07	0.10	8.28*	10.2	1.87	0.12	5.45*
10. STIMREAD	6.01	1.97	0.07	3.04*	8.18	1.50	0.10	5.44*	3.91	2.00	0.05	1.96*
11. EMOSUPS	5.14	1.44	0.06	3.58*	5.00	1.32	0.05	3.80*	-0.35	1.65	.00	-0.21
12. JOYREAD	4.87	2.06	0.06	2.36*	14.28	1.57	0.14	9.12*	7.92	1.88	0.09	4.22*
13. GFOFAIL	2.88	1.46	0.03	1.97*	5.60	1.37	0.06	4.07*	1.95	1.76	0.02	1.11
14. HISEI	0.11	0.11	0.03	0.96	0.11	0.09	0.03	1.28	0.19	0.15	0.05	1.33
15. DURECEC	-2.06	1.52	-0.02	-1.36	-0.96	1.23	-0.01	-0.78	-0.11	2.12	.00	-0.05
16. SCREADCOMP	2.09	1.9	0.02	1.10	-1.47	1.97	-0.01	-0.75	14.37	2.45	0.15	5.86*
17. GENDER_D2M	2.39	4.04	0.01	0.59	8.88	2.07	0.05	4.29*	8.55	3.95	0.05	2.16*
18. ATTLNACT	-0.73	1.31	-0.01	-0.56	1.93	1.12	0.02	1.73	2.21	1.57	0.03	1.41
19. BELONG	-1.01	1.53	-0.01	-0.66	-1.41	1.34	-0.01	-1.05	1.01	1.46	0.01	0.69
20. TEACHSUP	0.18	1.84	.00	0.10	0.93	1.77	0.01	0.53	7.28	2.61	0.08	2.78*
21. TMINS	.00	.00	.00	-0.17	0.02	0.00	0.09	5.05*	0.00	0.00	0.03	1.35

*Note: GENDER D2M: Dummy codded GENDER variable. * p< .05 (Two tailed) 1 R^2 = 0.41/ Adjusted R^2= 0.41/ s.e.= .02 2 R^2= 0.41/ Adjusted R^2= 0.41/ s.e.= .02 3 R^2= 0.39/ Adjusted R2 = 0.39/ s.e.=.03*

'learning time (minutes per week) - in total' are also significant variables for Chinese (B-S-J-Z) students and 14 significant variables explained 41% total variation in reading literacy of Chinese (B-S-J-Z) students. Except the 'highest education of parents', 'parents' emotional support perceived by student', and 'general fear of failure' variables, the rest of the significant variables for Turkish students are also significant for Mexican students. In addition to these variables, 'gender', 'self-concept of reading: Perception of competence', and 'teacher support in test language lessons' are also significant variables for Mexican students and 13 significant variables explained 39% total variation in reading literacy of Mexican students. As a result, 10 variables are significant for all three countries, 3 variables are significant for two countries, 4 variables are important for only one country, and 4 variables are significant for none of the three countries. The comparison of independent variables according to significance order is given in Table 2. The variables were ranked according to their standardized regression coefficient values. The insignificant variables were not included in ranking. Besides, Table 2 includes pairwise comparisons of countries in terms of standardized regression coefficients for each of independent variables.

In Table 2, it can be seen that 'Index of economic, social and cultural status', 'Meta-cognition: assess credibility', and 'Meta-cognition: summarizing' are the most significant factors affecting students' reading literacy in all three countries. In addition, irrespective of significance order, 'Teacher-directed instruction', 'Disciplinary climate in test language lessons', 'Self-concept of reading: Perception of difficulty', 'Perceived feedback', 'Meta-cognition: understanding and remembering', 'Teacher's stimulation of reading engagement perceived by student', and 'Joy/Like reading' are significant predictors of reading literacy of students from all three countries. 'Highest education of parents' variable is significant for only Turkish students; 'Learning time (minutes per week) - in total' variable is significant for only Chinese students; and 'Self-concept of reading: Perception of competence' and 'Teacher support in test language lessons' are significant variables for only Mexican students. 'Parents' emotional support perceived by student' and 'Joy/Like reading' are significant variables for both Turkish and Chinese (B-S-J-Z) students. 'Gender' is a significant variable for both Chinese (B-S-J-Z) and Mexican students. 'Index highest parental occupational status', 'Duration in early childhood education and care', 'Attitude towards school: learning activities', and

Table 2

Comparison of Variables with Respect to Significance Order Across Countries

	Rankings			Pairwise Comparisons (*z* values)		
Independent Variables	Turkey	China (B-S-J-Z)	Mexico	China (B-S-J-Z)-Turkey	Mexico-Turkey	China (B-S-J-Z)-Mexico
1. ESCS	1	2	1	-2.81*	-1.79	-0.55
2. METASPAM	2	1	2	0.45	-2.83*	4.02*
3. METASUM	3	3	3	-0.89	0.00	-0.89
4. DIRINS	4	6	6	1.06	0.28	0.55
5. DISCLIMA	5	8	7	-1.41	-0.35	-1.06
6. SCREADDIFF	6	7	10	0.89	1.06	-0.45
7. HISCED	6			2.80*	0.88	1.80
8. PERFEED	7	10	5	0.71	-1.77	2.47*
9. UNDREM	7	5	5	1.34	1.77	-0.89
10. STIMREAD	7	5	11	1.06	-0.71	1.77
11. EMOSUPS	8	10		-0.45	-2.12*	2.24*
12. JOYREAD	8	4	8	2.83*	1.06	1.77
13. GFOFAIL	9	9		1.34	-0.35	1.79
14. HISEI				0.00	0.40	-0.45
15. DURECEC				0.45	0.71	-0.45
16. SCREADCOMP			4	-1.06	3.61*	-4.44*
17. GENDER_D2M		10	11	1.79	1.41	0.00
18. ATTLNACT				1.34	1.41	-0.45
19. BELONG				0.00	0.71	-0.89
20. TEACHSUP			9	0.35	2.22*	-1.94
21. TMINS		6		3.18*	1.06	2.12*
R^2				0.00	1.97*	2.24*

Note. * *Independent variables are ordered based on standardized regression coefficients. *Values are significant at 0.05 level (two-tailed).*

'Subjective well-being: Sense of belonging to school' are not significant predictors for reading literacy of students from all three countries.

According to Table 2, while 'Index of economic, social and cultural status' and 'Highest education of parents' of Turkish students were more significant predictive variables than those of Chinese (B-S-J-Z) students, the opposite is true for the 'Joy/Like reading' variable. Similarly, 'Meta-cognition: assess credibility' and 'Parents' emotional support perceived by student' of Turkish students was a more significant predictive variable than those of Mexican students. While 'Meta-cognition: assess credibility' of Chinese (B-S-J-Z) students was a more significant predictive variable than those of Mexican students, the opposite is true for the 'Perceived feedback' variable. For the other variables, there were not statistically significant differences between any of two countries in predicting reading literacy. In addition, while total explained variance ratios (R^2) of the models were the same for China (B-S-J-Z) and Turkey, these two countries have significantly higher values than Mexico.

Prediction of Mathematics and Science Performance from Reading Literacy

In order to examine how reading literacy predicts mathematics and science performance, simple linear regressions were executed for data obtained from each country. Regression coefficients (*B*), standard errors of regression coefficients [*B (s.e.)*], standardized regression coefficients (β) and *t* values for each variable and country are given in Table 3.

The results in Table 3 indicate that reading literacy is a significant predictor of mathematics performance of Turkish, Chinese (B-S-J-Z) and Mexican students. Total variance explained is 65% for all three countries, which means that students' mathematics performance is highly affected by their reading literacy. Similar to mathematics performance, reading literacy also significantly predicts students' science performance for all three countries. Approximately 77% of the total variation in science performance is explained by reading performance for all three countries, which means that students' science performance is highly

Table 3

Simple Linear Regression Results for Mathematics and Science Performance

Dependent Variable: 1st to 10th Plausible Values in Mathematics						
	Independent Variables	R^2	*B*	*B (s. e.)*	*β*	*t*
China (B-S-J-Z)	Constant	.65	178.18	8.58		20.78*
	1st to 10th Plausible Values in Reading		.74	.02	.81	48.73*
Mexico	Constant	.65	92.97	7.15		13.01*
	1st to 10th Plausible Values in Reading		.75	.02	.81	46.93*
Turkey	Constant	.65	75.11	7.79		9.64*
	1st to 10th Plausible Values in Reading		.81	.02	.81	50.47*
Dependent Variable: 1st to 10th Plausible Values in Science						
	Independent Variables	R^2	*B*	*B (s. e.)*	*β*	*t*
China	Constant	.77	127.09	5.36		23.73*
	1st to 10th Plausible Values in Reading		.83	.01	.88	92.47*
Mexico	Constant	.77	90.95	6.13		14.85*
	1st to 10th Plausible Values in Reading		.78	.01	.88	57.00*
Turkey	Constant	.76	81.64	5.94		13.74*
	1st to 10th Plausible Values in Reading		.83	.01	.87	66.80*

*Note. * p< .05 (Two tailed)*

affected by their reading literacy. The total variance explained for science performance is higher than mathematics performance. In other words, the effect of reading literacy on science performance is higher than that of reading literacy on mathematics performance.

When standardized regression coefficients and total explained variance rates of regression models were statistically pairwise compared across countries, there were not any statistically significant differences between countries in predictivity of reading performance for both mathematics and science performances (*p*> .05)

Discussion

This research was carried out to reveal what the predictors of reading performance are according to PISA 2018 and to what extent reading performance is effective on mathematics and science performance of Chinese (B-S-J-Z), Turkish and Mexican students. First of all, it was found that the most important factors of reading literacy in all three countries are the 'index of economic, social and cultural status', 'meta-cognition: assess credibility', and 'meta-cognition: summarizing'. The index of economic, social and cultural status handles student-level variables (e.g., education levels of the student's parents, home conditions, reading skills) and school-level variables (e.g., the lack of qualified teachers, place of settlement, school type). Economic, social and cultural status is a highly important factor for good education, albeit being not always a valid measure of achievement. Other studies using PISA data (Erdoğan & Güvendir, 2019; Rajchert et al., 2014; Shala & Grajcevci, 2018) found that economic, social and cultural status had an impact on reading achievement. Regarding the child-level reasons for this impact, it is possible to say that the environment in which the child lives, the environment to which the child is exposed and the family support the child receives have an effect on reading achievement during the school period. Geske and Ozola (2008) found that the socioeconomic status of family had a significant impact on the educational status of the parents and the reading support they offered to the child in the preschool period. Moreover, it was stated that students with high literacy score come from families who spent more time for reading.

Several previous studies found that children from families with lower socioeconomic status start school at a disadvantage (Aikens & Barbarin, 2008; Hindman, Skibbe, Miller, & Zimmerman, 2010; Sirin, 2005). Students who start school in an unprepared and unsuccessful position and are not supported by their parents in this process are likely to face increasing problems in their school life (see Ferrer et al., 2015). Stanovich (1986) defines this situation as "Matthew effect" (rich-get-richer and poor-get-poorer patterns of reading achievement). To put it in another way, if students who start reading unsuccessfully and are not supported afterwards, there will be an ever-widening gap between those students and the successful ones in terms of reading achievement. Vice versa, it was found that children supported by their families in early literacy skills in the pre-school period start school in a more prepared way, which significantly contributes to their vocabulary and reading achievement in the following years (Manolitsis et al., 2013; Sénéchal, 2006; Sénéchal & LeFevre, 2002). In this context, if it is desired to create a positive change in students' reading skills in the light of PISA data, this change needs to be addressed starting from the pre-school period.

At the school level, it is observed that such factors as the lack of qualified teachers, school type and the region where the schools are located have an effect on reading achievement. The results of other studies also support the findings of the present research (Kır, 2016; Perry & McConney, 2010). This result raises questions over the "equality of opportunity" in education. The first reason for this result may be the fact that most of the countries conduct placements using central exams and grade point averages in transition from secondary to high school. This is the case for the countries included in the present research. Students with higher scores or grade point averages are enrolled in better high schools, while those with lower scores go to less successful high schools. Considering the PISA data from this point of view, it can be said that students who are good at reading receive education in more successful high schools, while those who are not good at reading receive education in less successful high schools. The second reason is that the level of economic development may differ among regions within countries. The eastern regions of Turkey are a bit less developed than the other regions of the country, for instance. Teachers appointed to work in these regions do not work there for a long time and want to be reappointed to other regions as soon as possible. As a consequence, students in these regions are deprived of more experienced and qualified teachers. It is not easy to eliminate this sort of negativities. Currently teachers in Turkey are obliged to work for four years at schools they are appointed to work. In addition, efforts are made to give incentives and to ensure that these regions are attractive for teachers who will work in there.

Secondly, other important factors affecting reading achievement were identified as 'Meta-cognition: assess credibility' and 'Meta-cognition: summarizing'. In a study using the PISA data, Artelt et al. (2001) found that metacognitive knowledge, decoding speed, and the number of books at home (as an indicator for family background) have considerable effects on reading comprehension, with the highest effects for metacognition. Several other studies also found that there is a close relationship between metacognition and reading achievement (Mikk, 2015; Miyamoto et al., 2019; Soodla et al., 2017). Students with metacognitive awareness know what strategies to use and when and where to use those strategies in the reading process (before, during and after) to better comprehend the text. This also requires students to make a plan to achieve the intended goal through selected strategies, to evaluate the progress accurately, to be monitored to make changes based on these evaluations, as well as to learn and evaluate these processes (Jacobs & Paris, 1987). When the literature is reviewed, it is stated that students with metacognitive skills are actively involved in the reading process, can make a guess before reading, use reading strategies, track their understanding, arrange the previous information in line with the new information and control what they learn (Pressley & Gaskins, 2006; Roberts, Torgesen, Boartmen, & Scammacca, 2008; Swanson, 1999). From this point of view, it is possible to say that metacognition is a prerequisite for reflective and strategic learning. Students' achievement in reading literacy in the PISA test can therefore be explained by metacognitive skills that ensure active participation in the reading process and require the use of high-level comprehension strategies.

Thirdly, it is a result of the present research that students' reading achievement significantly predict their science (77%) and mathematics (65%) achievement. This result supports the results of the studies revealing the relationship between reading and mathematics achievement (Erdem, 2016; Grimm 2008), as well as between reading and science achievement (Cromley, 2009; O'Reilly & McNamara, 2007). Reading skill can be considered as an effective tool for acquiring, organizing, and applying knowledge in different fields. Therefore, the ability to read and understand written materials is a "cross-curricular" competence and an important precondition for success in school (Artelt et al., 2001). Reed, Petscher and Truckenmiller (2017) found that the factor of reading ability (discourse comprehension and word comprehension) accounted for 70% of the variance in grades 5 and 8 science performance and 64% of the variance in grade 9 science performance. They also emphasized the importance of vocabulary in science achievement. In this context, it is necessary to emphasize the importance of vocabulary in comprehending such texts. Considering the reasons for this result in the present research, it is necessary to carry out a number of reading tasks from basic to complex levels in order for students to be successful in both mathematics and science. First of all, students are expected to comprehend the definitions or the problem in the text while reading about science and mathematics. They are sometimes expected to conceptualize, ratiocinate and apply the information they read. Through a successful reading, they can match, interpret and ably use the information in science and mathematics texts with the information presented in tables, diagrams or various figures. In addition, considering that successful readers have metacognitive skills and enjoy reading, it may be possible that students use these skills in other academic fields other than reading, such as science and mathematics. In other words, it can be thought that these skills of successful readers may have direct or indirect effects on science and mathematics achievement. Indeed, Ding and

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Homer (2020) showed that there is a significant relationship between the sub-dimensions of reading and mathematics achievement. It is possible to say that reading, mathematics, and science literacy skills are closely related in that regard, and it is not likely to develop a skill independently from another at an expected level. It is important therefore to develop reading, science, and mathematics skills together.
Finally, it was determined that the first three variables that predict the reading performance of Turkish, Chinese (B-S-J-Z), and Mexican students were the same. This result indicates that although the performance rankings of these countries are different, the factors affecting reading performance are similar. Therefore, countries that improve these three factors at the best level can be expected to be more successful in reading. Especially, it can be said that the education reforms made in recent years have an important effect on China's being the most successful country in the PISA study. Over the past fifteen years, China has been striving to transform their education from an exam-oriented system to one that values holistic and creative approaches to education and learning (Schulte, 2019). Therefore, it can be useful for other countries such as Turkey and Mexico which are aiming to be successful in PISA studies to examine the Chinese education system. On the other hand, it is a matter of criticism that China applies PISA only in a few developed provinces (Candido, Granskog, & Tung, 2020). In addition, other problems in the Chinese education system such as the course overload of students at schools, the emphasis on knowledge acquisition during the teaching process, and the prevalence of extracurricular education continue to be discussed (Yang & Fan, 2019).

Conclusions

The results obtained from PISA data indicate that the reading achievement of countries with high (China) and low (Turkey and Mexico) performance is affected by the same factors, which provides important clues about the variables that should be supported and/or changed to improve reading skills. So, what will be effective in improving reading skills at child- and school-level? It has been concluded that the socioeconomic status of family had a significant influence on the educational status of the students. Besides, family support received by the students significantly contributes to their reading achievement. From a school perspective, quality of schools in terms of opportunities for reading activities, school administration and teacher support, and collaboration with families is an important indicator for high level reading performance. Moreover, it has been observed that students with high metacognitive skills show high success in reading as well. Besides, reading related variables such as enjoying reading, teacher's stimulation of reading engagement, perception of difficulty, etc. were more effective in improving their reading performance. More importantly, supporting students' reading skills will contribute significantly to their development in other academic skills such as the ones in mathematics and science. The fact that these results obtained from three countries with different performance levels and characteristics have significant similarities indicates that they are generalizable.

Limitations and Implications

The results of this study are limited to the Chinese (B-S-J-Z), Turkish and Mexican students participating the PISA study (students aged 15 years). In future studies, the results obtained from the local exams of the countries can be compared with the PISA results. Supporting the findings obtained through interview, observation and experimental applications will contribute to a more concrete analysis of reading comprehension. The fact that science and mathematics performance is closely related to reading comprehension is an important issue that should be emphasized in the studies to be conducted in these areas.

In this study, we aimed to focus on reading from its predictors and its predictivity perspectives. Even if it seems those are two separate subjects, the common aspect of them were reading comprehension. Besides, it is possible to examine them separately or combine them in a more advanced structural model. Therefore, this situation was also a limitation of our study. In future studies, the relationship between predictors of reading literacy, reading literacy itself, mathematics and science performance can be examined by more complex structural models.

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Fitting a Mixture Rasch Model to Visual Sequential Processing Memory Sub-dimension of ASIS: The Role of Covariates

Murat Doğan Şahin*

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*Correspondance Details: Murat Doğan Şahin.
Anadolu University, Faculty of Education,
Department of Educational Sciences, Eskisehir, Turkey.
E-mail: mdsahin@anadolu.edu.tr
ORCID: http://orcid.org/0000-0002-2174-8443

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Abstract

Advanced Item Response Theory (IRT) practices serve well in understanding the nature of latent variables which have been subject to research in various disciplines. In the current study, 7-12 aged 2536 children's responses to 20-item Visual Sequential Processing Memory (VSPM) sub-test of Anadolu-Sak Intelligence Scale (ASIS) were analyzed with Mixture Rasch Model (MRM). In the first phase of the study, concomitant (covariate) variables were not used. In the second phase, age and gender were added to the model, and then the two models were compared in terms of fit indices, the number of latent classes and the distribution of item difficulties in the latent classes. The results of the study suggested that there were three latent classes in both models; however, the latter model had a better fit compared to the former model. In addition, the latent classes in both models had similar characteristics, and the distributions of item difficulties in the latent classes were also quite similar in both models while they had some differences in some aspects. The sizes of identical latent classes in both models varied between 15% and 30%. The results of the current study are expected to provide a deeper insight to researchers studying measurement theory and/or intelligence measurement.

Keywords:
Mixture Rasch Model, Concomitant/Covariate Variable, Latent Class, Visual Processing Memory

Introduction

New methods in measurement theory have a pivotal role in understanding the nature of latent variables which have been subject to research in various disciplines. In parallel with this view, new methods in measurement theory have been used in the measurement of intelligence which has a background of more than a century. Particularly advances related to Item Response Theory (IRT) continuously have offered critical advantages both theoretically and practically.

The sharpest advantage of IRT, when compared to Classical Test Theory (CTT), is the principle of parameter invariance. With IRT, ability prediction independent of items and item parameter prediction independent of groups are ensured (Embretson & Reise, 2000; Hambleton & Swaminathan, 1985).

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On the other hand, assuming the population from which item and ability parameters are predicted as a single homogenous population is a notable limitation for prediction through IRT. In fact, that a population consists of homogenous unknown sub-groups is a manifestation of this limitation (von Davier & Rost, 2017). This paves the way for new practices in IRT.

Another limitation for conventional IRT practices surfaces in bias studies (such as Differential Item Functioning-DIF). Although items providing advantage systematically to one of the groups of same ability level, or biased items in other words, can be identified with DIF studies, this practice is based on the assumption that the related groups are homogenous within themselves in terms of variables subject to measurement. Yet, it is known that individuals under the same manifest variable may consist of heterogeneous sub-groups (Samuelsen, 2005). Therefore, for whom items are biased cannot be identified and it cannot be understood for which reasons individuals respond differentially to items (Cohen & Bolt, 2005). This state comes along as another notable limitation for DIF practices based on manifest variables.

It can be argued that Mixture Rasch Model (Rost, 1990), which emerged through combining Rasch Model and latent class approach, offers a solution to these aforementioned limitations. Mixture Rasch Model (MRM) can be considered as a combination of latent class approach and IRT models (Frick et al., 2015). Accordingly, a continuous latent trait and latent class membership are predicted synchronously (Jiao et al., 2011). To put it another way, latent classes that are homogenous in itself but differ from other classes are identified, and group specific items and ability parameters are predicted in conjunction for these latent classes. Thus, it is postulated that invariance assumption is ensured for each latent class (Şen & Cohen, 2019). Compendiously, MRM combines classic Rasch models and latent class analysis and thereby it can exert item and ability parameters prediction for homogeneous sub-groups. This treatment provides identification of items showing DIF based on these latent classes, as well.

Another advantage of MRM is the use of concomitant variables. In the identification of latent classes, the effect of manifest covariate variables, also referred to as concomitant variables, on the formation of models can be tested, and which of these manifest variables have a notable contribution to the model can be revealed.

Within the scope of the current study, 20-item Visual Sequential Processing Memory (VSPM) sub-test of Anadolu-Sak Intelligence Scale (ASIS) was analyzed with MRM and how the item parameters in the latent classes differ was examined. In the second phase of the study, the participants' genders and ages were added to the model as covariates and the contribution of these manifest variables to the model was tested.

Visual Sequential Processing Memory

VSPM is one of the three sub-tests measuring memory capacity in ASIS. These tests focus on processing memory and short-term memory. The theoretical framework of processing memory model in ASIS is based on Baddeley (2012) aiming to measure visual memory bandwidth. It is known that processing memory correlates at a high level with learning and academic achievement. A number of performances including basic reading, comprehension, mathematical calculation and reasoning are dependent upon processing memory capacity (Alloway, 2009; Dehn, 2014). Visual processing memory has an active role in the development of particularly basic mathematical abilities in early ages (Geary, 2011). Therefore, it can be asserted that studies on processing memory can provide significant implications regarding academic abilities of individuals in age groups for which the measurement is performed.

The items in the sub-test are mostly geometric and focus on sequencing of different shapes. Participants are provided with a sequence of shapes for a few seconds and then they are expected to pick it out among other sequences. There are fewer shapes in the beginning of the test; however, the number of shapes increases through the end. Using some shapes for more than once, various shape patterns are formed in some sequences (ASIS Manual, 2016).

Rasch & Mixture Rasch

Rasch Model (Rasch, 1960), a member of IRT family, makes use of only difficulty parameter while defining a relationship between individuals' ability levels and their likelihood of responding to a binary item. Accordingly, the logit of the difference between a person's ability and item difficulty provides responding likelihood of the item. These parameters are in interval scale. To determine the starting point in this scale, a constant reference point is identified in a way that difficulty of an item or total difficulty of all items is zero (Fischer, 1995). Given a person's ability subject to measurement is θ_i and item difficulty is β_j, response y_{ij} given by person i for item j is modeled as following (Rasch, 1960):

$$P\left(Y_{ij} = y_{ij} \middle| \theta_i, \beta_j\right) = \frac{exp\{y_{ij}(\theta_i - \beta_j)\}}{1 + exp\{\theta_i - \beta_j\}} \quad (1)$$

Mixture model is a general approach used in order to model data which are thought to originate from different groups yet when membership to the group is not known. This modeling is as follows:

$$f(y_i) = \sum_{k=1}^{K} \pi_k \, f_k(y_i) \qquad (2)$$

$f_k(.)$ components in the formula may be densities or regression models. Mixture Rasch emerges with the combination of Formula 1 and Formula 2.

$$f(y|\pi,\ \psi,\ \theta) = \prod_{i=1}^{n} \sum_{k=1}^{K} \pi_k h(y_i|r_i, \beta_k)\psi_{ri}, k. \qquad (3)$$

In this model, also known as saturated model, a number of parameters that are not of concern in reality need to be predicted. Therefore, Rost and von Davier (1995) suggested a more parsimonious model based on only mean and variance when the number of items is more than four. In line with this, General Rasch Mixture Model turns out as:

$$f(y|\alpha,\ \theta,\ \gamma) = \prod_{i=1}^{n} \sum_{k=1}^{K} \pi(k|x_i, \alpha) h(y_i|ri, \beta_k) g(r_i|\gamma_i) \qquad (4)$$

The components in the formula are as follows:
$\pi(k \mid x_i, \alpha)$: Concomitant model for class membership,
$h(y_i \mid r_i, \beta_k)$: Class-specific likelihood of item difficulties,
$g(r_i \mid \gamma_i)$: Class-specific score distribution.

Use of concomitant variables affecting prior class membership is also possible in MRM, and whether adding these variables provides a notable fit in the model or not can be tested. Concomitant variables model predicts the mixture and the influence of covariates simultaneously, which stands out as a notable advantage in contrast to other approaches to reveal the relationship between class membership and covariates ex post (Frick et al., 2012).

Research Purpose and Significance

In the first phase of the present research study, the distributions of item difficulties were examined according to latent classes that were formed with respect to VSPM levels of 7-12 aged individuals. It was also attempted to reveal the nature of latent classes based on the difference in this distribution. In the second phase, the effect of adding covariates on model fit and the distribution of the item difficulties in the latent classes in this second model (concomitant model) were examined, and this distribution was compared with the distribution of difficulties in the first model. Accordingly, MRM analysis, which bears the same purpose with latent class analyses yet, which is a much more robust and relatively new method, was performed in the study.

A number of studies are extant in the literature aiming to predict ability and item parameters within the scope of IRT models in different aspects of intelligence tests (e.g., Beaujean & Osterlin, 2008; Ferreira et al., 2012; Schleicher-Dilks, 2015) or revealing bias through DIF practices (e.g., Abad et al., 2004; Colom et al., 2004; van der Sluis et al., 2008). On the other hand, it is also overt that Mixture IRT models are a better fit as opposed to conventional IRT models in cases when populations are not homogeneous (Muthén & Asparouhov, 2006). In this context, considering that a significant purpose of intelligence tests is to identify gifted individuals and categorize individuals in terms of related dimensions of intelligence test battery, it can be argued that the results to be obtained in the current study through MRM analysis would prove significant for the literature on measurement of intelligence.

VSPM is closely related to basic mathematics and language abilities of individuals in the 7-12 age groups. Herewith, the results of the study would also provide noteworthy findings for the researchers studying academic achievement of individuals in this age group. Additionally, this study is the first research study to examine the nature of latent classes that are formed through performing MRM analysis to an intelligence test and differentiation of item parameters among these classes.

Another purpose of the present study was to identify whether adding covariate variables to the model would cause a significant improvement in the model or not. To this end, ages and genders of the students who took the test were added to the model and thereby it was aimed to reveal the effect of these variables on both latent classes and obtained model parameters.

The current study sought to answer the following research problems. As a result of the MRM analysis;

1) How many latent classes are there in the first model? How are item difficulties distributed in terms of latent classes? In which context do the latent classes differ according to these distributions?

2) How do fit indices of the concomitant model which is formed through adding gender and age variables to the first model as covariates differ from the first model?

3) How are item difficulties distributed in concomitant model in terms of latent classes? In which aspects does this distribution differ from the first model or in which aspect are they similar?

Method

Participants

The data set used in this study was obtained from an implementation of Turkey norm study of ASIS, in which 4561 4-12 aged students from different regions of

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Turkey selected through considering statistical region units identified by Turkish Statistical Institute took the intelligence test. Within the scope of the current study, data of 2536 7-12 aged students, of whom the youngest attended to elementary education, were used out of the data in Turkey norm study of ASIS.

Data Collection Tools

In this study, responses to 20 items belonging to VSPM dimension of ASIS were analyzed. ASIS (2016) is an intelligence test with seven sub-dimensions, developed to be implemented with 4-12 aged individuals. The number of total items in ASIS is 256. The responses given to 20 items belonging to VSPM dimension, used in this study, were obtained from norm study of ASIS..

Data Analysis

To answer the research questions, MRM analysis was performed in the first phase using responses of 2536 students to 20 items. In this step, the analyses were run without using any manifest variables. It is recommended to exclude participants who responded correctly or incorrectly to all of the items from the analysis because they do not contribute to conditional likelihood of item parameters (Rost, 1990). Therefore, eight students who did not have any correct answers were excluded from the study and the analyses were performed with the data of 2528 participants.

In Mixture IRT models, like latent class analysis, there is not a priori exact decision regarding the number of groups to emerge. For this reason, a vector is formed for potential latent class number. This vector is composed of whole numbers starting from 1 and continuing till a potential maximum value in order to identify the optimum number of latent classes with an exploratory approach. The optimum number of latent classes is identified for the model with the help of fit statistics obtained for each latent class number. Since latent class models formed in MRM are not nested in each other, information-based indices are used to evaluate models. Model-data fit increases as these values decrease. Of these indices, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Integrated Completed Likelihood Criterion (ICL) were used within the scope of this study. It is recommended in the literature that when there are contradictions among them, BIC values which are less biased should be used (Cubaynes et al., 2012). Accordingly, the optimum number of latent classes was identified through considering BIC values primarily. In the next step, the distributions of estimated item difficulties for each latent class were examined, and in which contexts these latent classes differed was evaluated based on these distributions.

In the second phase of the study, the concomitant model was obtained through adding the participants' ages and genders to the model as covariate variables, and it was tested whether this new model had significant difference from the first model, which enabled the researcher to identify which of the manifest covariates could provide additional information. In the last phase, the similarities and differences of latent classes which emerged in the first and second models were put forth through examining item difficulty distributions in both models. The maximum number of latent classes was determined as four for both models.

The MRM analyses were run with psychomix (v1.1-8; Frick et al., 2012) package defined in R (R Core Team, 2020) with the method based on mean and variance of score distribution as suggested by Rost and von Davier (1995).

Results

Within the scope of the study, first, BIC values were obtained in order to decide on the number of latent classes for the first model in which manifest variables were not used (see Table 1). Since the lowest BIC value was obtained for three-class solution, it was decided that the optimum latent class number for the data set was three.

Table 1

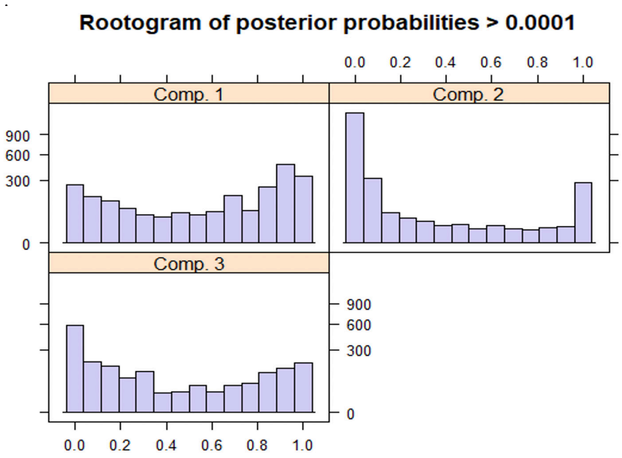
Fit Statistics for Different Number of Classes

Model	Number of Classes	Fit Indices		
		AIC	BIC	ICL
Model 1 (no covariate variables)	One class	39885.27	40007.81	40007.81
	Two classes	39105.26	39356.17	40171.90
	Three classes	**38613.89**	**38992.03**	**39811.67**
	Four classes	38693.62	39086.01	40131.71
Model 2 (Concomitant Model)	One class	39885.27	40007.81	40007.81
	Two classes	39004.16	39266.75	40085.41
	Three classes	**34998.89**	**35395.68**	**36105.01**
	Four classes	38442.66	38845.29	39517.65

With respect to VSPM, the participants were separated into three homogenous sub-groups. The histogram graph was also created to see posterior probabilities aiming to evaluate the three-component model (see Figure 1). In the U-shaped graph, the posterior distributions of the observations are seen as low or high, which reveals that the components (classes) are separated well enough at an acceptable level.

Figure 1

Rootogram of posterior probabilities in the 3-component (class) MRM on VSPM data



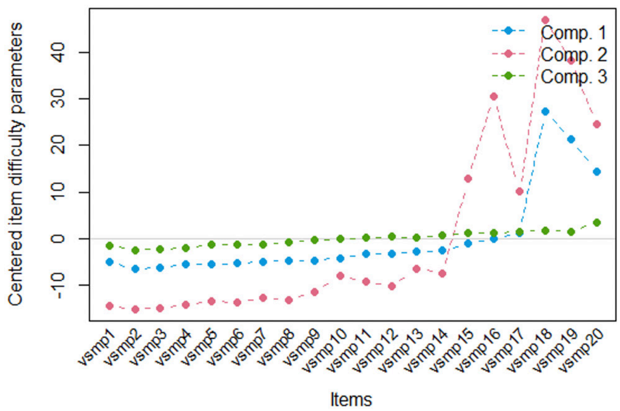
In the next step, the distributions of item difficulties for each latent class were obtained (see Figure 2). In the interpretation of the results, attention should be paid that the items are sequenced from simple to hard according to CTT item difficulties. In the examination of the obtained values, it is seen that item difficulty parameters of three classes are in parallel to a certain degree. Regarding the difficulties belonging to Class-2 (Component-2) shown in red, it can be argued that the first 14 items are perceived as easier for this class compared to other classes, and there is a relatively linear graph until this item. It catches attention that there are some bends between 10th and 14th items and there is a general increase in the difficulty values of the items. Starting with the 15th item, there are dramatic changes in difficulty values. Accordingly, it can be suggested that the last six items are very difficult for Class-2. The obtained difficulty values reveal that very few participants in this class could answer these items correctly.

With regard to difficulty parameters of Class-1 (Component-1), shown in blue, it is observed that the difficulty values of first part of the items for this class are between the values for the other two classes. In addition, it is seen that the values for Class-1 are in high parallelism with item difficulty parameters of Class-3. Such that, the difficulty levels of these two classes are very close to each other in the 15th and 16th items, and it is predicted as almost the same for the 17th item. However, starting with the 18th item, the case in the last three items is very similar to the case in Class-2, and there is a dramatic change in item difficulties. That the values obtained in Class-1 and Class-2 for the last three items are parallel to each other stands out. Finally, the difficulties obtained for Class-3 (component-3) were evaluated. The initial items have a difficulty level slightly below 0, and item difficulty levels are in a slightly increasing fashion as the number of items increase. Accordingly, it can be suggested that the item difficulties of Class-3 form a line graph with a small slope. What is remarkable for Class-3 is that there are not dramatic changes in the graphs, and the highest value of the item difficulties is 3.5

Following a detailed examination of the graphs, latent classes were named. Considering that the difficulty values obtained for all three classes are different from each other but the item parameters follow a similar path until certain items, as also highlighted in the interpretation of graphs, it can be deduced that the classes were formed according to the participants' VSPM levels. That the classes were formed in line with VSPM levels is also supported by the fact that in Class-1 and Class-2, there are dramatic increases in item parameters as the item difficulty level increases, which is higher in Class-2, and the fact that item difficulties form a graph which could be labeled as linear in Class-3. Accordingly, since there are dramatic increases in item difficulties in the last six items, it is considered that Class-2 is the group which has the lowest VSPM level, and Class-1, in which a similar case emerges in the last three items, consists of medium-level individuals. Finally, it can be stated that Class-3, in which item difficulty indices vary at a very narrower range compared to the other groups and in which extreme values are not observed even in the items that can be described as very difficult (The highest difficulty value obtained is 1.9 except for the last item with the value of 3.5), is the group with the highest VSPM level.

Figure 2

Item profiles for the 3-class MRM (Model-1) on VSPM data



In the second phase, the variables of gender and age were added to the model as covariate variables to answer the second and third research questions.

In the examination of fit indices (see Table 1), it was observed that, as the case in the first model, the lowest values were also obtained with three latent classes in this concomitant model which was formed through adding the manifest covariates. Therefore, it was deemed appropriate to compare three latent classes in both models. As mentioned beforehand, in mixture models, likelihood ratio test cannot be used in order to decide on the number of components. However, a comparison between the two models could be carried out with this test because the first model with three latent classes in which covariate variables were not used was nested in the second (concomitant) model which was also formed with three latent classes. The likelihood ratio test which yields a test statistics of 1809.93 ($p< .001$), reveals that the concomitant model have a much better fit than the first model. In other words, the covariate variables improved the model significantly.

Another property of psychomix (Frick et al., 2012) package is that it can identify which of the covariates that formed the concomitant model have more effect on the formation of latent classes. As a result of the analysis to this end, it is observed that both covariates have effect; however, the absolute effect of age is greater than gender.

In the final phase of the study, the distribution of item difficulties obtained for latent classes in the concomitant model was examined (see Figure 3), and in which aspect this distribution differed from the first model was revealed.

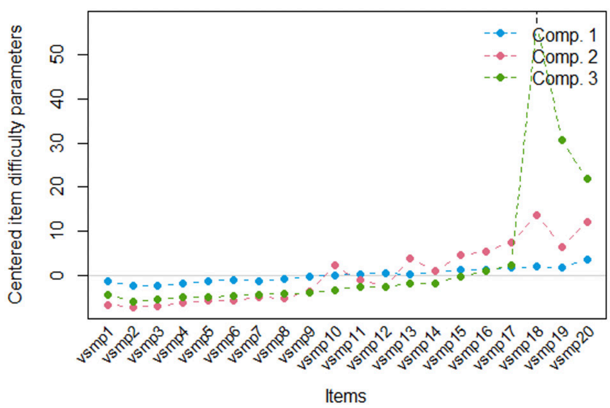
In this distribution, as in the first model, it is seen that the difficulty levels belonging to the initial items, in particular, are parallel to each other. However, differently from the first model, the item difficulty levels of the classes are much closer to each other. In particular, it is observed that item difficulty levels of Class-3, shown in green, and Class-1, shown in red, are very close to each other for the first ten items. It is also observed that the difficulty values of Class-2 have a rippled pattern starting with the 10th item and they get very high values starting with the 15th item. The horizontal pattern followed by the difficulty values of the initial items and the change in 10th-14th items lend their support to the fact that Class-2 is identical with the Class-2 in Model-1. On the other hand, it is also evident that the great change in the item difficulties in the first model starting with the 15th item is also observed in the concomitant model; however, this change is relatively less aggressive in the latter model. It is possible to say that Class-1 and Class-3 are identical with Class-3 and Class-1 in the first model, respectively. Accordingly, similar to the first model, the difficulty levels of these two classes progress in parallel with each other, they get closer to each other and they get almost the same value in the 17th item. It is observed that there are dramatic increases in the item difficulty values for the last three items in Class-3, as is for the Class-1 which is its counterpart in the first model. Class-1 has a very similar distribution with Class-3 which is its identical in the first model.

The results of the current study indicate that the classes were formed in line with VSPM levels in a similar way with the first model. The number of the classes is the same and these classes are similar to their counterparts in the first model with respect to various characteristics. In particular, for Class-1, which consists of students with high VSPM level, very similar graphs were obtained in both models. The item difficulty levels of Class-2, involving students with the lowest VSPM level, started with higher values compared to the first model. It was also observed that the changes seen in the final items were not as dramatic as the changes in the first model. The difficulty distributions obtained in the class which included students with medium VSPM level were similar to the distributions in the first model; however, the amount of increase in the difficulty values of the last three items (differently from the first model) were much more higher than the values of Class-1.

To compare the first and second models, lastly, the numbers of individuals in the classes in the first and second models were compared. Accordingly, it was revealed that the class in the concomitant model which consisted of individuals with low VSPM levels expanded by 28% compared to the first model. The class in the concomitant model which consisted of individuals with medium VSPM levels expanded by 32% compared to the first model. Finally, the class consisting of individuals with high VSPM levels was examined and it was found out that it decreased by 15% compared to the first model.

Figure 3

Item profiles for the 3-class MRM (Model-2) on VSPM data



Discussion and Conclusion

Within the scope of the current study, VSPM sub-test of ASIS battery was analyzed with MRM. In the first phase of the study, no covariate variables were used. The number of latent classes was decided as three and it was evaluated that the latent classes which were obtained through their difficulty distributions were formed according to the individuals' VSPM levels as low, medium and high. In the second phase, the concomitant model was formed through adding gender and age variables as covariates, optimum number of classes was found as three as well, and it was observed that the covariate variables improved the model significantly compared to the fist model. Of these variables, it was revealed that age had a higher contribution to the model and gender had a relatively lower contribution. In the second model, similar to the case in the first model, the latent classes were formed according to the individuals' VSPM levels as low, medium and high. The comparison of the item difficulty distributions of identical classes in both models suggested that they were mostly similar yet some items differed to some degree. Accordingly, after adding covariate variables to the model, changes were observed in the distribution of item difficulties of some items. Besides, it was concluded that the membership number of classes that had similar characteristics in both models changed in the range of 15% and 30%.

The results obtained in this study were first examined with respect to the use of covariate variables in MRM analysis. It was highlighted in some former studies that adding manifest covariates contributed to identification of latent classes in Mixture IRT models, revealing the differences among these classes (e.g., Choi et al., 2015; Li et al., 2016), and prediction of parameters (Dai, 2013). The findings in the present study overlap with some of these studies. On the other hand, it was observed that the manifest covariate variables used in this study had an effect on class membership to some degree but they did not cause a change in the number of classes. This finding is in agreement with those obtained by Karadavut et al. (2019).

The finding of the current study that age and gender had a high degree of contribution to the model, gender with a greater degree, is in line with those of previous studies in the literature. A number of studies unearth that there is increase in individuals' visual processing memory and tasks related to it until the ages of 11-12 (Brockmole & Logie, 2013). Heyes et al. (2016) observed that visual processing memory improved precision in middle childhood. There are other studies in the literature lending support to this finding (Cowan et al., 2010; Cowan et al, 2011). Voyer et al. (2017), who put forth the relationship between visual processing memory and gender with a comprehensive meta-analysis study, reported that visual processing memory differed significantly in terms of gender yet this was at a very low level.

The studies in the literature broadly lend their support to the effect of covariate variables on the model identified in the current study. Yet these studies predominantly depend on CTT based measurements. In the studies aimed at measuring intelligence, as in the current study, the use of MRM analysis may contribute more to understanding the nature of the characteristic subject to measurement.

The present study focused on visual processing memory which is a critical aspect of intelligence. On the other hand, this would be a fruitful area for further work. Future studies may exert similar procedures for the other aspects of intelligence. It may be interesting to identify the changes in the model when different manifest variables other than gender and age or latent covariates are added, and compare these changes with findings of the current study.

The factors affecting the development of children's basic reading and basic mathematics abilities have always been a major area of interest for researchers. The current study dwelled on a factor that is known to be closely related to basic reading and mathematical abilities. Further research should be undertaken to explore different aspects of intelligence that may be closely related to children's academic achievement.

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Effect of Inquiry-Based Learning Method Supported by Metacognitive Strategies on Fourth-Grade Students' Problem-Solving and Problem-Posing Skills: A Mixed Methods Research*

Ramazan Divrik[**,a], Pusat Pilten[b], Ayşe Mentiş Taş[c]

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[**,a]**Correspondance Details:** Ramazan Divrik.
Ministry of National Education, Afyonkarahisar, Turkey.
E-mail: rdivrik42@gmail.com
ORCID: http://orcid.org/0000-0002-7126-7664

[b]Pusat Pilten. Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan.
E-mail: ppilten@ayu.edu.kz
ORCID: http://orcid.org/0000-0001-6032-5526,

[c] Ayşe Mentiş Taş. Ahmet Keleşoğlu Faculty of Education, Necmettin Erbakan University, Konya, Turkey.
E-mail: aysementistas@hotmail.com
ORCID: http://orcid.org/0000-0002-1175-812X

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Abstract

This study aimed to evaluate the effectiveness of the inquiry-based learning method supported by metacognitive strategies on students' problem-solving and problem-posing skills. The research was conducted in two stages using an exploratory sequential design, which is one of the mixed methods research. The case study design was used in the first stage, while the quasi-experimental design with the pretest and posttest for control group was employed in the second stage. The method that is considered effective in students' gaining problem-solving and problem-posing skills was determined in the first stage. In the second stage, the designated method supported by metacognitive strategies was tested with 63 fourth-grade students. The data for the first stage of the study were collected through interviews held with 12 primary school teachers, the mathematics curriculum, and a group of 10 experts' opinions on the methods in the relevant literature. A content analysis and Lawshe's method were employed to analyze the data at hand. Data in the second stage were collected using the problem-solving skills test and problem-posing skills test. The Mann–Whitney U test was used in the analysis of unrelated measurements, whereas the Wilcoxon signed ranks test was employed in the analysis of related measurements. The analysis results in the first stage revealed that the inquiry-based learning method might be effective in improving students' problem-solving and problem-solving skills. Thus, it was decided to utilize this method in the second stage. The results of the analysis in the second stage showed that the inquiry-based learning method supported by metacognitive strategies and the inquiry-based learning method could be effective in developing students' problem solving and problem-posing skills. Moreover, it was concluded that the methods applied were more effective in developing problem-solving skills and structured problem-posing skills of the students from sub-dimensions compared to the control group, but not effective in the development of semi-structured and free problem-posing skills from sub-dimensions.

Keywords:
Problem-Solving, Problem-Posing, Methods and Techniques, Inquiry-Based Learning, Metacognitive Strategies

Introduction

Problem-solving and problem-posing are considered two important skills located at the center of the mathematics curriculum (Ministry of National Education [MoNE], 2018; National Council of Teachers of Mathematics [NCTM], 2000). While problem-solving is defined as the process of finding an appropriate solution for a new and more complex situation using students' previous knowledge (Baykul, 2014; Mayer, 2002; NCTM, 2000); problem-posing is defined as the developing new questions or problems to discover a particular situation and creating new problems based on the solution of a given problem (Cai & Hwang, 2002; English, 2003; Silver, 1994).

Problem-solving is a meaningful learning process that expands, deepens, and consolidates mathematical knowledge (MoNE, 2015). Problem-posing is also as important as problem-solving and even an important endeavor that involves mathematical inquiry beyond problem-solving skills (Gonzales, 1998; Silver & Cai, 2005). Researchers claimed that there is a close relationship between problem-solving and problem-posing skills in development of mathematical thinking and creativity, and these skills support each other (Gonzales, 1998; Kilpatrick, 1987; Lowrie, 2002; Rosli, 2013; Stoyanova, 2005). Therefore, problem-solving and problem-posing activities should be frequently included to develop students' mathematical creativity (Kilpatrick, 1987; Mamona-Downs, 1993).

To provide students with problem-solving and problem-posing skills, problem-solving and problem-posing should be addressed as a process rather than a subject or task (NCTM, 2000; Stoyanova & Ellerton, 1996). Therefore, learning environments should be organized in such a way that allows students to be occupied with problems and creative. Due to the importance attributed to problem-solving and problem-posing and comprehensive teaching of such skills, it is emphasized that classroom environments should be created where students are able to solve problems in various ways and share their thoughts about the problem-solving and problem-posing process with their teachers and peers easily (MoNE, 2005; 2018). For this purpose, students' problem-solving and problem-posing skills were examined by designing different learning environments (Akkaş, 2014; Divrik, 2020; Erümit, 2014; Kanbur Tekerek & Argün, 2019; Karataş & Baki, 2017; Katrancı, 2014; Polat, 2009; Rosli, 2013; Turhan & Güven, 2014; Yazlık, 2015). In this study, the inquiry-based learning method, a student-centered teaching approach enabling students to create their questions and structure their knowledge, was used (Hammerman, 2006; Keller, 2001; Llewellyn, 2002).

The inquiry-based learning method is a technique in which teachers present a problem and students try to solve the problem by collecting data for the problem. This method enables students to ask questions, investigate, analyze information, and transform the data into useful information (Perry & Richardson, 2001; Woolfolk, 2001). Studies revealed that lessons taught with an inquiry-based learning method have a positive effect on students' behaviors and motivations (Camenzuli & Buhagiar, 2014; Caswell & LaBrie, 2017; Kogan & Laursen, 2013; Yavuz et al., 2018; Zhang, 2015). The same studies revealed that students' mathematics achievement increased, their anxiety levels decreased, and they enjoyed these lessons.

Studies also underscored the need to make arrangements that enable students to develop their metacognitive knowledge and skills and manage their own learning processes consciously (Aşık, 2015; Erdoğan, 2013; Goldberg & Bush, 2003; Nelson, 2012). In this context, another element to be useful in mathematics teaching is metacognition, which is defined as thinking about thinking (Blakey & Spence, 1990). Metacognition means the knowledge of the structure and operation of one's cognitive system and an individual's awareness of planning, monitoring, and evaluation processes in solving a mathematical problem (Flavell, 1979; Özsoy, 2007; Pugalee, 2001; Schoenfeld, 1987; Senemoğlu, 2013).

Some metacognitive strategies are used to create a supportive classroom environment that will encourage the development of students' metacognitive skills and enable them to take responsibility for their learning (Barın, 2016; Georghiades, 2004; Lin, 2001; Tian, 2016; Vula et al., 2017; Weaver, 2012). These strategies are defined as a series of processes used to control cognitive effectiveness in achieving a specified goal (Flavell, 1979; Gama, 2004; Schraw, 1998; Schraw & Moshman, 1995). Therefore, students have the opportunity to make the necessary planning, monitoring, and evaluating their learning processes while performing this series of procedures. In this respect, it would be worthwhile to conduct comprehensive research on the use of metacognitive strategies for primary school students.

In line with the aforementioned context, the study used two different methods. The first method was the inquiry-based learning method, while the second one was the inquiry-based learning method supported by metacognitive strategies. These methods are considered to improve the fourth-grade students' problem solving and problem posing skills. Thus, the study aimed to investigate the effect of these two methods on students' problem solving and problem posing skills. The study, in this context, has the following research questions:

For fourth-grade students to gain problem-solving and problem-posing skills:

1. Which method can be effective according to teachers' opinions?

2. Which method can be effective considering the directions in the curriculum?

3. Which method can be effective considering expert opinions on the methods in the relevant literature?

4. Does the improvement of their problem-solving skills differ significantly?

5. Does the improvement of their problem-posing skills (structured, semi-structured, and free) differ significantly?

Methodology

Research Design

In this research, an exploratory sequential mixed method design was used. In this design, priority is given to collecting and analyzing qualitative data and the process begins with them. According to the findings, the researcher begins applying the second stage, the quantitative stage, and tests or generalizes the primary results. They explain how they build quantitative data on primary qualitative data (Creswell & Plano-Clark, 2015).

In this study, a single-case research design, where more than one sub-dimension or unit in a single case nested, was used to obtain primary qualitative data (Yin, 1984). While the case studied here was to determine the method that could be effective in teaching problem-solving and problem-posing skills, the units of analysis of the case were the opinions of teachers, the curriculum, and expert opinions on the methods included in the relevant literature. Considering the best method that could be effective in developing students' problem-solving and problem-posing skills, the study adopted this method for the second stage of the research.

In collecting and analyzing quantitative data as a secondary case, a quasi-experimental study was conducted in the trial model with the pretest and posttest control group. Studies that used experimental model tested the effect of the experimental process on the dependent variable. Thus, they added a high statistical power to the research and allowed the findings to be interpreted in the context of cause and effect (Büyüköztürk, 2012). In the experimental section, the effect of activities conducted with the inquiry-based learning method supported by metacognitive strategies and inquiry-based learning on the problem-solving and problem-posing skills of fourth-grade primary school students was examined.

Study Group

The study group in the qualitative part of the study consisted of 12 primary school teachers and the mathematics curriculum. Criterion sampling, one of the purposeful sampling methods, was used to determine primary school teachers. The basic understanding of this type of sampling is to examine the situations that meet a predetermined set of criteria (Yıldırım & Şimşek, 2006). For this purpose, a list of criteria was prepared by the researchers. These criteria were listed as the inclusion of three teachers from each grade level in the research. Teachers were selected from different schools in a district center and villages. The selection of the teachers was made by considering the socio-economic characteristics of the schools, tenure of teachers, and educational degree of the teachers, and the expression of the teachers that they paid attention to the application of different methods in mathematics courses.

The study group in the quantitative part consisted of 63 fourth-grade students studying in three classes in the second semester of the 2017–2018 academic year. In the experimental part of the study, two experimental groups and a control group were determined as the effects of two independent variables (inquiry-based teaching supported by metacognitive strategies and inquiry-based teaching) on dependent variables (problem-solving and problem-posing skills) were investigated.

In determining the experimental and control groups, the first-term mathematics grade averages of the three classes were examined. As a result of the exploration, the average of mathematics achievement of the classes was calculated as 82.72, 80.15, and 79.86. According to these averages, the mathematics achievements of the groups were found to be equivalent.

After the groups were determined to be equivalent, two experimental groups and one control group were selected by the neutral assignment method. Twenty-two students (10 girls [45.45%] and 12 boys [54.55%]) were included in the first experimental group; 20 students (nine girls [45%], 11 boys [55%]) were included in the second experimental group; and 21 students (12 girls [57.1%] and nine boys [42.9%]) were included in the control group. These data show that the numbers of students in the experimental and control groups were equal and the distribution of the participants in the study groups by gender within the groups was close to each other.

Data Collection Tools

Semi-structured interview form

This form consisted of the following two dimensions: personal information and interview questions. The personal information dimension of the form aimed to collect demographic information of the participants, such as gender, tenure, educational degree, and grade level that the participants teach were provided. Besides, an open-ended question was added to the interview question part of the questionnaire, aiming to collect data in accordance with the purpose of the research. Furthermore, expert opinions were consulted while preparing the form.

While developing the form, a draft form consisting of two questions was prepared first. Later, a pilot study was conducted by applying this draft form to two primary school teachers. During the pilot study, primary school teachers reported that the two questions were similar. Thus, these two questions were decided to combine. As a result of these studies, a final form consisting of the following single question was obtained: Is it possible to apply different methods in mathematics classes for students to gain problem-solving and problem-posing skills by considering the grade level that you teach, and could you please explain how these methods should be?

Form for expert opinion

This form included approaches, methods, and techniques that can be used in mathematics teaching by scanning the relevant literature. An expert group of 10 people was formed to fill in this form. This expert group included mathematics teachers, primary school teachers, and academicians who conducted studies on mathematics education. The expert group was asked to evaluate the methods and techniques that could be effective in teaching problem-solving and problem-posing skills by using this form.

Problem-solving skills test and problem-posing skills test

The problem-solving skills test developed by the researchers consisted of 15 problems and the problem-posing skills test consisted of 15 problem-posing situations. All questions in the problem-solving skills test consisted of open-ended questions. The questions included in the problem-posing skills test consisted of structured, semi-structured, and free problem-posing situations (five pieces for each). A structured problem-posing presents a problem and poses a new problem out of it. A semi-structured problem posing is developing a new problem from a problem situation using instruments such as raw information, graphs, pictures, and tables. A free problem-posing is to pose a problem about the desired subject without giving any problem, data, figure, or problem situation. The problems and problem-posing situations in the tests consisted of questions in the learning domains of addition, subtraction, multiplication, division, and length measurement. In this way, it was aimed to enable students to solve and pose problems by using their four operations skills.

The opinions of three faculty members and eight primary school teachers were taken in the process of forming the tests. The Cronbach's alpha (α) values of the problem-solving skills test for the first experimental group, the second experimental group, and the control group were .90, .91, and .75, respectively. The Cronbach's alpha (α) value for the problem-posing skills test for the first experimental group, the second experimental group, and the control group were .89, .86, and .94, respectively.

Rubrics for the evaluation of problem-solving and evaluation of problem-posing

These rubrics were developed by Katrancı (2014) to evaluate problem-solving skills and consist of five criteria. The rubrics aimed to evaluate the problem-solving processes of the students better by separating each criterion into sub-criteria. The highest score that students could get from this rubric for each question was 5, while the lowest score was 1. The Cronbach's alpha value of the rubric was 0.925. The rubrics for the evaluation of problem-posing included four sub-dimensions and each dimension consisted of four criteria. The assessment criteria of the sub-dimensions were evaluated between 0 and 4 points, and each sub-dimension had the coefficients of the evaluation criteria. Thus, it is possible to observe them in detail in which stage they have deficiencies while evaluating students' problem-posing studies. The highest score that students could get from this rubric for each question was 14, whereas the lowest score was 0. The Cronbach's alpha score of the rubric was 0.932.

Observation forms for the evaluation of experimental procedures

They were developed by the researchers to evaluate the teaching performed in the experimental groups. The forms were created by considering the application steps of the methods applied in the experimental groups. The aim was to set criteria for determining whether the experimental applications were functioned as planned or not.

Observation form for the evaluation of studies conducted in the control group

The form was developed by the researchers to observe the problem-solving and problem-posing activities in the control group. Problem-solving and problem-posing activities performed in the control group during the experimental process were determined through this form.

Data Collection Process

In the qualitative part, interviews were conducted with primary school teachers first. Each interview lasted approximately 30–40 minutes. Briggs (1986) stated that the interviewing, which is widely used in the field of social sciences, is an effective data collection method for obtaining information about individuals' experiences, opinions, complaints, feelings, attitudes, and beliefs (cited in Yıldırım & Şimşek, 2006). Thereafter, the mathematics curriculum was examined through document analysis. According to Wiersma and Jurs (2005), document analysis is a technique used for data collection, systematic analysis, and evaluation of data.

Finally, the relevant literature was reviewed to determine teaching approach and techniques that could be employed in mathematics teaching. After the expert group was informed about the methods and techniques, they were asked to evaluate these methods and techniques that could be effective in teaching problem-solving and problem-posing skills. The data obtained from the experts were converted into statistical data using Lawshe's technique (critical values for Lawshe's content validity ratio) to determine the content validity ratios. Thanks to these rates, the methods that could be used were determined. The obtained data are presented in the findings section.

Furthermore, pretest and posttest were applied to the students in the experimental and control groups of the problem-solving skills test and problem-posing skills test to collect the quantitative data. The tests were applied to the students with similar characteristics to identify the response time of the tests and it was concluded that the two class hours (40 + 40 min) would be sufficient for the tests.

An (inquiry + metacognition) application process for the first experimental group

In the first experimental group, the application of an inquiry-based learning method supported by various metacognitive strategies was performed. The application was implemented for nine weeks by performing problem-solving and problem-posing activities in one class hour each day. One problem was solved and formed in each class hour. Forty-five problem-solving and 45 problem-posing practices were performed in 45 class hours. In addition, through the homework guide form, 20 problem-solving and 20 problem-posing practices were distributed to the students to solve them at home. In total, the students completed 65 problem-solving and problem-posing practices.

Various metacognitive strategies were used to develop students' metacognitive skills in the inquiry-based learning environment, and thus, various materials were designed by the researcher by taking the expert opinions. These materials are problem-solving with guidance card / problem-posing worksheet, problem-solving with behavior card / problem-posing worksheet, problem-solving / problem-posing worksheet, checklist, error evaluation form, peer evaluation form, reflective journal writing form, homework guide form, and self-assessment scale. These materials consisted of questions that improve students' metacognitive skills while solving and posing problems. After reading a problem or problem situation, the students solved and formed the problems by answering the questions included in each inquiry tread.

The second experimental group (inquiry) application process:

In the second experimental group, the process, including only the inquiry steps, was applied without performing metacognitive strategy teaching. In determining these steps, the inquiry steps introduced to encourage the application and use of inquiry-based learning in mathematics and science by bringing together 14 universities from 12 countries in Europe were used (Promoting Inquiry in Mathematics and Science Education Project [PRIMAS], 2010). In the practice process based on inquiry, worksheets, containing the same problems and problem-posing situations as the first experimental group were prepared as materials. The students completed 45 problem-solving and problem-posing activities for each in the classroom within 45 class hours and completed 20 problem-solving and problem-posing activities for each at home. The students completed a total of 65 problem-solving and problem-posing activities. However, expressions that improved metacognitive skills were excluded from these worksheets. The students were allowed to perform problem-solving and problem-posing practices in accordance with the steps of "simplification and representation," "analyzing and solving," "interpretation and evaluation," "communicating and reflecting," and "reviewing the process."

The control group application process

No instructional planning was made in the control group, and the normal process based on the textbook continued. However, during the teaching process in the control group, the students also dealt with the same problems and problem-posing situations used in the experimental groups. In addition, 20 problem-solving and problem-posing activities were provided for them to be solved at home.

Data Analysis

A content analysis was used to examine the interviews with the teachers and the mathematics curriculum, while the Lawshe's technique was used to analyze the expert opinions. The procedure in the content analysis was to bring similar data within the framework of certain concepts and themes together and interpret them in a way that the reader could understand (Yıldırım & Şimşek, 2006). In the content analysis, the teachers' names obtained during the interview process were kept confidential and were coded as T1, T2, T3, ... T12. Page numbers in the direct quotations obtained from the mathematics curriculum were given in the following form: pg.1, pg.2.

Lawshe's technique was used to analyze the expert opinions. A minimum of five and a maximum of 40 expert opinions are received through this technique (Yurdugül, 2005; Yurdugül & Bayrak, 2012). The opinions of the expert group were scaled into the following three categories: "necessary," "useful but unnecessary," and "unnecessary." The calculation was then made over the number of experts who reported the item "necessary" (Ayre & Scally, 2014).

Content validity ratios (CVR) were obtained by 1 minus of the ratio of the number of experts reporting the opinion of "necessary" for any item to the half of the total number of experts providing opinions on the item (Lawshe, 1975). CVRs varied between +1 to −1. Ratios with 0 and negative values were directly excluded (Yurdugül, 2005). As the opinions from 10 experts were received in this study, the content validity criterion was found to be "0.62," and the evaluations were made according to this criterion in the findings section.

In the quantitative section, the pp graph, skewness, and kurtosis values were examined to determine whether the data showed a normal distribution to select the appropriate statistical method for the study and to decide the statistical procedures to be applied. The skewness/the standard error of skewness was found to be >1.96 and, thus, the data set variables did not show a normal distribution. Therefore, the Mann–Whitney *U* test was used to analyze unrelated measurements in the comparison of pretest and posttest scores of the students in the experimental and control groups, and the Wilcoxon signed ranks test was used in the analysis of related measurements. The error margin in the research was accepted as .05.

In addition, the effect sizes were calculated to determine to what extent the independent variables affect the dependent variables. The effect size is a value used to determine how effective an examined case is (Yıldırım, 2015). In non-parametric tests, the effect size, as mentioned by Field (2009), was calculated using the formula $r = z/\sqrt{N}$, and they were interpreted as small effect, moderate effect, and strong effect with the values of $r = 0.10$, $r = 0.30$, and $r = 0.50$, respectively.

Results

The Results of the First Stage of the Study

In the first sub-problem of the study, interviews with teachers were conducted to determine the method that could be effective for fourth-grade students to gain problem-solving and problem-posing skills. The findings obtained from the interviews with teachers are presented in Table 1.

As Table 1 presents, the opinions of teachers were grouped under six categories. During the creation of categories, the codes were identified, and expressions were analyzed according to these codes. Two teachers (16.66%) reporting students could learn better with fun activities said that game-oriented methods could be effective. Two teachers (16.66%) said that the methods that attract more students to arouse their interest and help them use their imagination could be efficient.

Three teachers (25%) reported that the methods that could develop different perspectives could be effective in problem-solving and problem-posing practices. Two teachers (16.66%) mentioned that the methods that could be understood by the students at different levels with low-attendance and attention deficit could be impressive. Two teachers (16.66%) reported that the use of the methods in which the problem solutions are explained step-by-step could be effective. Furthermore, one teacher (8.34%) reported that students should have different problem-solving and problem-posing methods to form and solve problems.

The findings of the analyses regarding the second sub-problem of the study are presented in Table 2. When Table 2 was analyzed, eight categories regarding the methods emphasized in the statements in the program were identified. The details of these categories revealed the following assumptions:

Table 1
The Opinions of the Teachers Concerning the Applicability of Different Methods

Category	*f* (%)	Code	Teacher statements
Game-based	2 (16.66)	Game	T6: The methods that students turn into a game and understand entertainingly might be used while solving the problem. T1: The visual activities should be more for students with high visual intelligence. Game-based methods should be included.
Attractive	2 (16.66)	Attention	T2: Yes, the activities in the textbook seem very superficial and ordinary. I would like methods that would draw children's attention more and would make them use their imagination more to be included. T8: As the practices in the book are very few, the presence of the methods that attract the students' attention would increase diversity.
The one containing different viewpoints	3 (25)	Method	T4: I think that the methods that allow for posing more problems would be effective. By this means, the students could both pose and solve a problem they have created by developing different viewpoints. T11: The student would choose the shortest path to the solution or the most appropriate way for their comprehension when solving or forming a problem. In this respect, the introduction of different paths is important. Furthermore, the methods that could contribute to the teacher's development of distinct ideas and increase the student's attention. T9: In mathematics course, we make the students deal with a great variety of questions. As every problem has absolutely a few solutions, it would be good to have the methods that bring in different perspectives.
Suitable for a level	2 (16.66)	Level	T7: Teaching could be easier if there were e different methods that can be easily understood by the students with low attendance and with attention deficit. T5: The comprehension and understanding level of each student f is not the same. Therefore, different methods could appeal to different students.
The one including process steps	2 (16.66)	Step-by-step	T12: In particular, the students with difficulties understanding what they read while reading information about the problem. They have problems with misapplying the information and inability to express it adequately. It could be good to use paths with different process steps to eliminate these issues. T3: The number of examples should be increased, and the existence of different methods would enable the students to understand the stages of problem-posing. Thus, the student will be able to solve and form the problem more easily. Because books are inadequate on this subject.
The one including fiction	1 (8.34)	Fiction	T10: Of course, the sample problem should be placed on the page so that the student fictionalizes and solves it. Moreover, it would be better to reduce page densities visually and increase the numbers.
Total	12 (100)		

the program emphasized the methods that direct the use of metacognitive knowledge and skills, in which time is effectively used, a teacher is a guide when needed, could be built on previous learning, individual differences are taken into account, active participation is provided and is open to necessary adaptations, could be effective.

In the third sub-problem of the research, expert opinions concerning the methods in the relevant literature, which could be effective in equipping fourth-grade students with problem-solving and problem-posing skills, were examined. In determining these methods, Lawshe's technique was used to analyze the answers provided by the experts. The content validity ratio was 0.62 as 10 experts participated in the research. The methods that took a value above this rate were identified as effective methods in teaching problem-solving and problem-posing skills. The findings regarding expert opinions are presented in Table 3.

Table 3 shows the content validity ratios of the methods presenting the expert opinions. According to these ratios, the methods that are above the 0.62 content validity ratio calculated in the method section were considered effective methods. The methods with the highest value were identified as the inquiry-based learning and problem-solving method. Also, the observation method, micro-teaching, simulation technique, six hat-thinking technique, role-playing method, demonstration method, show and tell method, and direct instruction method, which took 0 and negative values, were also determined as the methods and techniques that should not be used.

The findings obtained from the first stage of the research revealed that the activities should not be performed by rote learning methods that do not encourage the student to conduct research and think. Therefore, it has been observed that student-centered methods should be preferred in which students actively participate in the learning process, pose their

Table 2

Expressions in the Program Regarding the Method that Could be Effective

Category	Code	Teacher statements
Making using the time efficiently	Time	"To pursue and insist on learning so that the individuals could organize their act of learning individually or in groups, including effective time and knowledge management" (pg. 6).
Guidance prepared by:	Support	"Gaining, processing, and adopting new knowledge and skills as well as looking for guidance support and take advantage of it…" (pg. 6).
Revealing preliminary information	Preliminary information Guidance	"Based on previous learning and life experiences to use and apply knowledge and skills in various contexts such as home, workplace, education, and training environment" (pg. 6). ' 'Students' prior learning should be identified and opportunities for students to build new mathematical concepts on previous concepts should be provided through the activities that support effective learning and students should be encouraged in this process"(pg. 15). "In the process of learning mathematical concepts, it is necessary and important for teachers to guide students to express their thoughts. In this context, through questions such as 'Have you ever encountered a problem similar to this problem? If so, do you remember the path you followed? Do you know what path would work to solve this problem?' the student should be allowed to demonstrate and strengthen the thinking process" (pg. 15).
Including diversity	Genuine	"As the individual is severely affected by internal and external dynamics such as educational level, course content, social environment, and school facilities, the priority in ensuring the effectiveness of measurement and evaluation practices is expected from teachers and training practitioners, instead of the curricula. At this point, originality and creativity are the basic expectations of the teachers" (pg. 7).
Safeguarding individual differences	Interest Requirement Development Measurement and Evaluation	"Due to the fact of individual differences, it is not appropriate to speak of a uniform method of measurement and evaluation involving all students, and de facto for all students. The academic development of the student cannot be evaluated by measuring a single method or a technique" (pg. 7). "Individual differences derived from hereditary, environmental, and cultural factors manifest themselves also in terms of interest, need, and orientation. Alternatively, this includes inter-individual differences and differences within the individual. Individuals differ both from others and are different from their characteristics. While an individual's abstract thinking ability is strong, the same individual's painting ability could be weak" (pg. 8). "Although development continues throughout life, the rate of this development varies according to the stages. Times, when the speed is high, are the risky and critical times in terms of development. Therefore, teachers are expected to be more sensitive to the situation of the student when the development speed is high" (pg. 8). "Students' individual differences should not be neglected. Therefore, priority and importance should be given to the practices that put forward students' learning styles and strategies in mathematics teaching studies" (pg. 14).
The one providing active participation	Participation Communication	"Multi-focused measurement-evaluation is essential. The measurement and evaluation practices are performed by the active participation of the teachers and students" (pg. 7). "In the process of teaching and learning mathematics, the fact that students express their thoughts verbally plays an important role in internalizing, understanding, and structuring mathematical concepts. Students should also be encouraged to establish individual and inter-individual communication while demonstrating how they construct concepts in the teaching process" (pg.15).
The one comprising necessary adaptations	Development Teacher Method	"Although development continues throughout life, it is not in a single and an exemplary structure. It proceeds as phases and the developmental characteristics of individuals are different in each stage. The phases are not homogeneous in terms of their beginnings and endings. For this reason, the programs are structured with the utmost precision to take this into account. In the process of realizing the objectives and gains of the programs, the necessary adaptations are expected to be made by the teacher" (pg. 7). "The individual and cultural differences among students should be considered in the implementation process of the program. In this context, appropriate methods and approaches should be preferred in the mathematics-teaching process" (pg.15).
Making use of metacognition	Problem-solving Reasoning Action	"The students will be able to express their thoughts and reasoning easily in the process of problem-solving and see deficiencies or gaps in the mathematical reasoning of other" (pg. 9). "Education is given not only for 'knowing (thought),' but also for 'feeling (emotion)' and 'doing (action),' therefore, only cognitive measures cannot be considered sufficient" (pg. 7).

Table 3

The Content Validity Ratios of Expert Opinions (CVR)

Approach/ Method/ Technique	Appropriate	I am undecided	Inappropriate	CVR	Approach/ Method/ Technique	Appropriate	I am undecided	Inappropriate	CVR
Inquiry-based learning	10	0	0	1	Direct instruction method	1	2	7	–.8
Peer learning method	9	1	1	.8	Question and answer method	7	0	3	.4
Active learning	9	0	1	.8	Problem-solving method	10	0	0	1
Programmed instruction	6	3	1	.2	Demonstration method	2	5	3	–.6
Computer-aided instruction	7	1	2	.4	Observation method	5	2	3	0
Micro-teaching	4	1	5	–.2	Role playing method	4	2	4	–.2
Teaching by team	9	0	1	.8	Case study method	7	2	1	.4
Simulation technique	4	2	4	–.2	Discussion method	6	3	1	.2
Six thinking hats technique	4	2	4	–.2	Show and tell method	2	2	6	–.6
Brainstorming technique	7	1	2	.4	Group working method	9	0	1	.8
Station technique	6	1	3	.2	Project method	8	1	1	.6

questions, work in collaboration by combining new information with previous information, and that is also entertaining, individual differences are supervised, communication is encouraged, and a teacher guides when necessary.

One of these methods in the first stage of the research was the inquiry-based learning method determined by analyzing teachers' opinions, the mathematics curriculum, and expert opinions. The inquiry-based learning method is a student-centered method in which students use their creativity in the process of creating knowledge by asking questions and conducting research. In the second stage of the study, an experimental study was designed to determine the effect of this method on students' problem-solving and problem-posing skills. In this designed experimental process, the effect of inquiry-based learning method supported by metacognitive strategies and inquiry-based learning method on students' problem-solving and problem-posing skills were examined.

The Results of the Second Stage of the Study

The fourth sub-problem of the study was examined to determine whether there was a significant difference between the pretest and posttest scores of the problem-solving skills of the experimental and control groups.

The findings of the Mann–Whitney U test conducted for the analysis of the problem- solving skills pretest scores of the experimental and control groups are shown in Table 4.

Table 4 shows that there was a statistically significant difference in favor of experimental group 1 between the experimental group 1 and the control group before the practices (U= 62.50, z= −4.09, p< .05), between the experimental group 1 and experimental group 2 in favor of experimental group 1 (U= 101, z= −3.00, p< .05). The findings also revealed that there was no statistically significant difference between the experimental group 2 and control group (U= 145.50, z=

Table 4

Analysis of Pretest Scores in Problem-Solving Skills

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	29.66	652.50	62.50	.00*
Control	21	13.98	293.50		
II. Experiment	20	24.23	484.50	145.50	.09
Control	21	17.93	376.50		
I. Experiment	22	26.91	592	101	.00*
II. Experiment	20	15.55	311		

−1.68, *p*> .05). The mean scores of the groups revealed that the problem-solving skills of the first experimental group were higher than the second experimental group and the control group before applying the learning methods. It would be safe to say that the problem-solving skills of the second experimental group and the control group equaled to each other.

The results of the Mann–Whitney *U* test conducted for the analysis of the problem-solving skills posttest scores of the experimental and control groups are shown in Table 5.

According to Table 5, after the experimental practices, the problem-solving skills of the students in the experimental group 1 compared to both the students in the control group (*U*= 46.50, *z*= −4.48, *p*< .05, *r*= −.68), and in the experimental group 2 (*U*= 95.50, *z*= −3.14, *p*< .05, *r*= −.48) showed a statistically significant difference. In addition, the problem-solving skills of the experimental group 2 students were found to be higher than the control group (*U*= 117, *z*= −2.43, *p*< .05, *r*= −.53). The effect size values revealed that the inquiry-based learning method supported by metacognitive strategies and inquiry-based learning significantly improved students' problem-solving skills compared to the learning process envisaged by the curriculum. Moreover, the inquiry-based learning method supported by metacognitive strategies improved students' problem-solving skills at a moderate level compared to the inquiry-based learning method.

The findings of the Wilcoxon signed ranks test conducted to determine whether there was a statistically significant difference between the problem-solving skills pretest and posttest scores of students in the experimental and control groups are shown in Table 6.

Table 6 shows that, in the experimental and control groups, a statistically significant difference was observed in favor of posttest scores (*z*= −3.42, *p*< .05, *r*= −.52; *z*= −3.92, *p*< .05, *r*= −.62; *z*= −3.45, *p*< .05, *r*= −.53). The effect sizes of this difference revealed that the students' problem-solving skills showed a statistically significant improvement in all three groups.

The purpose of the fifth sub-problem of the research was to determine whether there was a statistically significant difference between the pretest and posttest scores of the problem-posing skills of the experimental and control groups.

The results of the Mann–Whitney *U* test conducted for the analysis of the structured problem-posing skills sub-dimension pretest scores of the experimental and control groups are presented in Table 7.

According to Table 7, no statistically significant difference was observed (*U*= 201, *z*= −.73, *p*> .05; *U*= 207.50, *z*= −.06, *p*> .05; *U*= 175, *z*= −1.13, *p*> .05). The mean ranks of the groups revealed that structured problem-posing skills were equivalent in each of the three groups before the application of learning methods.

Table 5

Analysis of Posttest Scores in Problem-Solving Skills

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	30.39	668.50	46.50	.00*
control	21	13.21	277.50		
II. Experiment	20	25.67	513	117	.01*
control	21	16.57	348		
I. Experiment	22	27.16	597.50	95.50	.00*
II. Experiment	20	15.28	305.50		

Table 6

Analysis of Pretest and Posttest Scores in Problem-Solving Skills

Groups	*Pretest posttest*	n	Mean rank	Rank total	z	p
I. Experimental group	Negative ranks	3^a	7	21	−3.42*	.00
	Positive ranks	19^b	12.21	232		
	Equal	0^c	-	-		
II. Experimental group	Negative ranks	0^a	.00	.00	−3.92*	.00
	Positive ranks	20^b	10.50	210		
	Equal	0^c	-	-		
The control group	Negative ranks	3^a	4.17	12.50	−3.45*	.00
	Positive ranks	17^b	11.62	197.50		
	Equal	1^c	-	-		

The results of the Mann–Whitney U test conducted for the analysis of the structured problem-posing skills sub-dimension posttest scores of the experimental and control groups are presented in Table 8.

According to Table 8, after the experimental applications, both the students in the experimental group 1 (*U*= 128.50, *z*= −2.49, *p*< .05, *r*= −.38), as well as the students in experimental group 2 (*U*= 131.50, *z*= −2.06, *p*< .05, *r*= −.32) structured problem-posing skills showed a statistically significant difference compared to the students in the control group. However, there was no statistically significant difference between the students' structured problem-posing skills in the first and second experimental groups (*U*= 199.50, *z*= −.52, *p*> .05). The effect size values revealed that the inquiry-based learning method supported by metacognitive strategies and inquiry-based learning methods improved the students' problem-posing skills at a moderate level compared to the learning process predicted by the curriculum. However, the inquiry-based learning method supported by metacognitive strategies was not more effective compared to the inquiry-based learning method.

The results of the Wilcoxon signed ranks test conducted for the students in the experimental and control groups regarding whether there was a statistically significant difference between the structured problem-posing skills sub-dimension pretest-posttest scores are shown in Table 9.

According to Table 9, in the experimental and control groups, a statistically significant difference was found in favor of posttest scores (*z*= −4.11, *p*< .05, *r*= −.62; *z*= −3.92, *p*< .05, *r*= −.62; *z*= −3.42, *p*< .05, *r*= −.53). According to the effect size values of this difference, the students' structured problem-posing skills showed a statistically significant improvement in all three groups.

Table 7

The Analysis of Pretest Scores in the Structured Problem-Posing Skills Sub-Dimension

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	20.64	454	201	.47
Control	21	23.43	492		
II. Experiment	20	21.13	422.50	207.50	.95
Control	21	17.26	362.50		
I. Experiment	22	19.45	428	175	.26
II. Experiment	20	23.75	475		

Table 8

The Analysis of Posttest Scores in the Structured Problem-Posing Skills Sub-Dimension

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	26.66	586.50	128.50	.01*
Control	21	17.12	359.50		
II. Experiment	20	24.93	498.50	131.50	.04*
Control	21	17.26	362.50		
I. Experiment	22	22.43	493.50	199.50	.60
II. Experiment	20	20.48	409.50		

Table 9

The Analysis of the Pretest and Posttest Scores in the Structured Problem-Posing Skills Sub-Dimension

Groups	*Pretest posttest*	n	Mean rank	Rank total	*z*	*p*
I. Experimental group	Negative ranks	0^a	.00	.00	−4.11*	.00
	Positive ranks	22^b	11.50	253.00		
	Equal	0^c	-	-		
II. Experimental group	Negative ranks	0^a	.00	.00	−3.92*	.00
	Positive ranks	20^b	10.50	210.00		
	Equal	0^c	-	-		
The control group	Negative ranks	2^a	8.50	17	−3.42*	.00
	Positive ranks	19^b	11.26	214		
	Equal	0^c	-	-		

The results of the Mann–Whitney *U* test conducted for the analysis of the semi-structured problem-posing skills sub-dimension pretest scores of the experimental and control groups are presented in Table 10.

According to Table 10, before the practices among the groups, no statistically significant difference was observed (U= 187.50, z= –1.06, p> .05; U= 173.50, z= –.95, p> .05; U= 216, z= –.10, p> .05). The results of the mean ranks of the groups revealed that the semi-structured problem-posing skills were equivalent in each of the three groups before the application of learning methods.

The outcomes of the Mann–Whitney U test conducted for the analysis of the semi-structured problem-posing skills sub-dimension posttest scores of the experimental and control groups are shown in Table 11.

According to Table 11, after the experimental applications, no statistically significant difference was observed between the groups (U= 208.50, z= –.55, p> .05; U= 162, z= –1.25, p> .05; U= 180 z= –1.01, p> .05). The results of the mean ranks of the groups revealed that semi-structured problem-posing skills did not differ in all three groups after the implementation of learning methods.

The findings of the Wilcoxon signed ranks test conducted to determine whether a statistically significant difference between the pretest and posttest scores of the sub-structured problem-posing skills sub-dimension of the students in the experimental and control groups is presented in Table 12.

According to Table 12, in the experimental and control groups, a statistically significant difference was found in favor of posttest scores (z= –3.49, p< .05, r= –.53;

Table 10

The Analysis of the Pretest Scores in Semi-Structured Problem-Posing Skills Sub-Dimension

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	23.98	527.50	187.50	.29
Control	21	19.93	418.50		
II. Experiment	20	22.83	456.50	173.50	.34
Control	21	19.26	404.50		
I. Experiment	22	21.32	469	216	.92
II. Experiment	20	21.70	434		

Table 11

The Analysis of the Posttest Scores in Semi-Structured Problem-Posing Skills Sub-Dimension

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	23.02	506.50	208.50	.58
control	21	20.93	439.50		
II. Experiment	20	23.40	468	162	.21
control	21	18.71	393		
I. Experiment	22	19.68	433	180	.31
II. Experiment	20	23.50	470		

Table 12

Analysis of Pretest and Posttest Scores of the Semi-Structured Problem-Posing Skills Sub-Dimension

Groups	*Pretest posttest*	*n*	Mean rank	Rank total	*z*	*p*
I. Experimental group	Negative ranks	4[a]	4.75	19	–3.49*	.00
	Positive ranks	18[b]	13	234		
	Equal	0[c]	-	-		
II. Experimental group	Negative ranks	1[a]	1	1	–3.88*	.00
	Positive ranks	19[b]	11	209		
	Equal	0[c]	-	-		
The control group	Negative ranks	4[a]	4.50	18	–3.25*	.00
	Positive ranks	16[b]	12	192		
	Equal	1[c]	-	-		

z= −3.88, *p*< .05, *r*= −.61; *z*= −3.25, *p*< .05, *r*= −50). According to the effect size values related to this difference, the students' semi-structured problem-posing skills showed a statistically significant increase in all three groups.

The results of the Mann–Whitney *U* test conducted for the analysis of the free problem-posing skills sub-dimension pretest scores of the experimental and control groups are shown in Table 13.

According to Table 13, before the practices among the groups, no statistically significant difference was observed (*U*= 230.50, *z*= −.01, *p*> .05; *U*= 168.50, *z*= −1.08, *p*> .05; *U*= 176.50, *z*= −1.10, *p*> .05). When the mean ranks of the groups are observed, it can be stated that free problem-posing skills were equivalent in each of the three groups before the application of learning methods.

The results of the Mann–Whitney *U* test conducted for the analysis of the free problem-building skills sub-dimension posttest scores of the experimental and control groups are presented in Table 14.

According to Table 14, after experimental applications, no statistically significant difference was observed between the groups (*U*= 167.50, *z*= −1.54, *p*> .05; *U*= 142, *z*= −1.77, *p*> .05; *U*= 209.50, *z*= −.26, *p*> .05). When the mean ranks of the groups are examined, it can be stated that the free problem-posing skills did not differ in all three groups after the application of learning methods.

The results of the Wilcoxon signed ranks test conducted to determine whether a statistically significant difference between the pretest-posttest scores of the students' free problem-posing skills sub-dimension in the experimental and control groups is presented in Table 15.

Table 13

Analysis of Pretest Scores of the Free Problem-Posing Skills Sub-Dimension

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	21.98	483.50	230.50	.99
Control	21	22.02	462.50		
II. Experiment	20	23.08	461.50	168.50	.28
Control	21	19.02	399.50		
I. Experiment	22	19.52	429.50	176.50	.27
II. Experiment	20	23.68	473.50		

Table 14

Analysis of Posttest Scores of the Free Problem-Posing Skills Sub-Dimension

Groups	*n*	Mean rank	Rank total	*U*	*p*
I. Experiment	22	24.89	547.50	167.50	.12
Control	21	18.98	398.50		
II. Experiment	20	24.40	488	142	.08
Control	21	17.76	373		
I. Experiment	22	21.02	462.50	209.50	.79
II. Experiment	20	22.03	440.50		

Table 15

Analysis of Pretest and Posttest Scores of Free Problem-Posing Skills Sub-Dimension

Groups	*Pretest posttest*	*n*	Mean rank	Rank total	*z*	*p*
I. Experimental group	Negative ranks	1[a]	7	7	−3.77*	.00
	Positive ranks	20[b]	11.20	224		
	Equal	1[c]	-	-		
II. Experimental group	Negative ranks	5[a]	4.60	23	−3.06*	.00
	Positive ranks	15[b]	12.47	187		
	Equal	0[c]	-	-		
The control group	Negative ranks	7[a]	11.21	78.50	−.99*	.32
	Positive ranks	13[b]	10.12	131.50		
	Equal	1[c]	-	-		

According to Table 15, in the first experimental group, ($z= -3.77$, $p< .05$, $r= -.57$) and in the 2nd experimental group ($z= -3.06$, $p< .05$, $r= -.48$), there was a statistically significant difference in favor of posttest scores, while no statistically significant difference ($z= -.99$, $p> .05$) was observed in the control group. Also the effect size values revealed that the first experimental group was found to make significant progress in the problem-posing skills, while the second experimental group showed moderate improvement. However, the learning process envisaged by the curriculum was not effective in the development of free problem-posing skills of the students in the control group.

Conclusion and Discussion

By examining the teachers' opinions, the curriculum, and the relevant literature, the method that could be effective in making the students gain problem-solving and problem-posing skills were determined as the inquiry-based learning method. The inquiry-based learning is seen as a process in which the problems or questions are formed, and the students, during the course, try to solve problems or find answers to the problems (Hammerman, 2006; Llewellyn, 2002; Wood, 2003).

The findings revealed that the courses carried out with the inquiry method increased students' success, developed their scientific process skills, led to a positive attitude toward the course of science and technology, developed their learning of concept, improved their academic self-efficacy, and inquiry-based activities were applicable in the preschool period (Çakar, 2013; Duban, 2008; Eti, 2016; Gençtürk & Türkmen, 2007; Kayacan, 2014; Ünal, 2018).

According to these results, the application of inquiry processes foreseen by the curriculum allows students to structure their knowledge by developing independent questions. Based on these results, the inquiry-based learning method was adopted as the method used in the second part of the study.

The findings of the second part of the study revealed that the methods applied in the experimental groups were more effective than the control group and improved the students' problem-solving skills. Among the applied methods, it was concluded that the inquiry-based learning method supported by metacognitive strategies was more effective than the inquiry-based learning method.

The courses carried out with the inquiry-based learning method supported by metacognitive strategies have an effect on the improvement of students' problem-solving skills. In a similar vein, Izzati and Mahmudi (2018) emphasized that metacognition is necessary to solve mathematical problems successfully. They found that students with higher metacognition are also better problem-solvers. Goldberg and Bush (2003) claimed that the metacognition process used in mathematical problem solving improves students' problem-solving performance and metacognition skills. Özsoy (2007) examined the effect of metacognitive strategies teaching on the students' success in problem-solving stages suggested by Polya. The findings revealed that teaching metacognitive strategies through metacognitive problem-solving activities increased students' problem-solving success.

Mevarech and Kramarski (1997) argued that the IMPROVE strategy, a metacognitive strategy, used in their study contributed to the students' success in some areas such as mathematical thinking, problem-solving, and reasoning. Vula et al. (2017) claimed that the use of metacognitive strategy and self-regulation processes was effective on students' actions, reasoning, and reflections. The findings of these studies coincide with the findings of this research. Thus, it would be safe to say that the use of various metacognitive strategies in the problem-solving process improves the students' problem-solving skills. The strategies used in the problem-solving process help the students decide which steps to complete the task and transmit their experiences to the subsequent tasks, as these strategies are conscious, and they contain awareness and control. Moreover, materials prepared to use these strategies (guidance card worksheet, behavior card worksheet, problem-solving worksheet, peer assessment form, etc.) could be considered factors that improve students' problem-solving skills.

It was observed that the activities performed by the inquiry-based learning method were effective in improving students' problem-solving skills. Polat (2009) argued that the interrogative problem-solving approach improves students' problem-solving skills, offers new solutions through in-class discussions and teaches them to think differently. These results are also consistent with the results of this study. Furthermore, previous studies demonstrated that the effect of inquiry-based learning on unsuccessful students' grades was strong and permanent (Kogan & Laursen, 2013), the students enjoyed the lessons during the inquiry-based learning process, there was an improvement in their behaviors and motivations, and their success of mathematics increased (Camenzuli & Buhagiar, 2014; Caswell & LaBrie, 2017), and the questioning skills of the teacher trainees and their anxiety levels related to the mathematics teaching had an inverse relationship (Yavuz et al., 2018).

The findings on the students' problem-posing skills revealed that the applied methods were more effective in developing students' structured problem-posing skills among the groups. No statistically significant difference was observed among the groups in the other sub-dimensions. Furthermore, while studies conducted on the sub-dimensions developed the students' structured, semi-structured, and free problem-posing skills in all three groups, no improvement was observed in the students' free problem-posing skills only in the control group. This situation revealed that studies conducted in the experimental groups were effective, whereas inadequate in the control group.

The materials concerning how the activities would be performed in the experimental groups (error evaluation form, checklist, reflective journal writing form, etc.) were considered the factors that improved students' problem-posing skills. Tertemiz and Sulak (2013) argued that most of the students developed problems by changing the values of the data at hand without changing the technical conditions and the subject. It was identified that there would be no problem in the classifications of "reversing the given and requested information" and "changing the conditions without changing the given data and the subject."

Ngah et al. (2016) found that free problem-posing was a more challenging task than semi-structured and structured problem-posing situations. Similarly, Özgen et al. (2017) found that while there was no statistically significant difference between students' ability to construct different problems, it was found that the students had more difficulty in the free problem-posing activities. According to these results, it would be safe to say that the results obtained in this research were similar to the results of the relevant studies. The main reason for this is that, in structured problem-posing skills, the students could produce problems more easily than the ready-made problem situations. Although there were raw data such as pictures, tables, and figures for students to use in semi-structured problem situations, they had difficulties in forming problems by combining these data. Likewise, in the cases of free problem-posing, the limited information that would serve as an example for students led them to have difficulty in developing problems. Therefore, it would be useful to include different problem-posing activities frequently in mathematics classes.

Teachers' inadequate information about the problem-posing can be considered one of the reasons why students cannot develop problems related to different problem situations. Işık and Kar (2012) found that primary school mathematics teachers included structured and semi-structured problem-posing activities in the process of the course, whereas they did not engage in free problem-building activities. The other reason would be the insufficient number of activities in the textbooks for students to work with different problem situations. Fewer problem-posing activities prevent students from being productive by seeing different problem situations. Regarding this subject, Işık (2010) found that the problem-posing strategies in mathematics textbooks have not reached the desired prevalence level yet.

Arıkan and Ünal (2013) argued that the students could not develop a problem in line with the desired situation and that this was due to the fact that the problem-posing activity in the book is not appropriate for students' readiness levels. According to Cai and Jiang (2016), the problem-posing tasks should be included more in the textbooks both in China and the US, depending on the class levels, the problem-solving diversity, and the designs of problem-solving tasks. Ev-Çimen and Yıldız (2017) pointed out that the problem-posing activities in all textbooks that they examined were included in a limited number and variety in all textbooks except for the eighth-grade textbook of a private publishing company. In addition, it was observed that the problem-posing activities were not in a balanced distribution in sub-learning areas and that there was no textbook covering all learning areas and all types of problem-posing. Therefore, it would be effective to include an adequate number of different problem-posing activities in mathematics textbooks.

Suggestions

• Methods that encourage students to conduct research and solve problems should be preferred by the teachers to help students gain problem-solving and problem-posing skills.

• Learning environments should be prepared by the teachers in which the students could activate their metacognition skills in the process of asking questions, researching, analyzing information, and transforming data into useful information in the problem-solving and problem-posing stages.

• Organizing pre-service and in-service training might help teachers and prospective teachers learn about metacognition and inquiry-based learning.

• It will be beneficial for the teachers and students to use the materials developed by the researchers to improve metacognition in the learning process.

• Training can be organized for the teachers to design and implement in-class practices in which different problem-posing activities are conducted.

• Problem-posing skill is as important as problem-solving skill and it should not be considered separately from problem-solving skill. Therefore, by considering this situation in teacher training programs, the arrangements should be made for the importance of problem-posing in the problem-solving process and the improvement of problem-posing skills.

• In this research, as a result of experimental practices, students' problem-solving and problem-posing skills development were examined. In addition, further studies would be helpful to examine the effect of students' problem-forming skills on problem-solving skills.

• The inquiry-based learning method supported by metacognitive strategies was conducted in a quantitative dimension. Future studies employing qualitative methods could examine the views of teachers and students about this process.

• This research was conducted in accordance with the problem-solving and problem-posing gains in primary school fourth-grade mathematics course. Experimental research can be conducted in different subject areas, courses, and grade levels using the inquiry-based learning method supported by metacognitive strategies.

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Appendix

I. EXPERIMENTAL GROUP GUIDANCE CARD WORKSHEET

Problem: Göktuğ is now 18 years old. Age of his father is 3 times the age of Göktuğ. In two years, what will be the sum of their ages?

Simplify and Represent

1. Read aloud a few times until you understand the problem and underline important information.

2. Is there an expression in the problem that you do not know the meaning of? If so, what is it?

3. Write down what was given and what was asked? Do you think there is some missing or unnecessary information about the problem?

4. Can you write down what you understand from the problem, what you are asked to do?

5. Which information, methods, and tools can be used to solve the problem?

6. Is it difficult for you to solve the problem before you start solving it? If yes, why is it difficult?

Analyze and Solve

1. Have you previously solved a problem similar to this one? If so, can you explain in what way it is similar?

Solve the Problem:

2. Which steps you followed to solve the problem?

3. What did you use to solve the problem? (chart, table, figure, etc.)

Interpret and Evaluate

1. Is the result you found correct? How do you verify it is correct?

2. If your answer is wrong, where do you think you have made a mistake?

3. Are there any places you have difficulty or need to reevaluate while solving?

Communicate and Reflect

1. Can you summarize what you have learned from the problem?

2. Could you solve the problem in another way?

3. Do you think this study will be useful for solving other problems?

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II. EXPERIMENTAL GROUP PROBLEM POSING WORKSHEET

Problem Situation: Duru reads 25 pages on the first day, 30 pages on the second day, and 50 pages on the third day.

Develop a problem that includes addition and subtraction by adding new information and data to the information in the problem.

Let's Simplify the Problem Situation: To better understand the problem situation, look at what is given, and which variables are listed. S/he tries to understand the problem situation by creating simpler questions.

Let's Analyze the Problem Situation: Have I encountered such a problem before to pose the problem? S/he connects with previous information. S/he draws visuals, tables, and graphics that facilitate problem-posing. Each group develops a problem in accordance with its plan.

Let's Pose the Problem:

Let's Interpret and Evaluate the Posed Problem: S/he checks whether the problem is correct. The data related to the problem e.g., tables, graphs are transferred to forms. If s/he's not sure of her/his problem, s/he'll go back to the beginning.

Let's Present and Reflect the Posed Problem: S/he effectively explains and shares the problem s/he has developed in the classroom. S/he tells if there are alternative problems. S/he tells her/his relationship with other problems. Finally, s/he keeps the report.

Process Review: The importance of the process is emphasized by talking and discussing the problem-posing process.

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Preschool Teachers' Promotion of Self-Regulated Learning in the Classroom and Role of Contextual and Teacher-Level Factors

Seda Saraç[*,a], Betül Tarhan[b]

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[*,a]**Corresponding Author:** Seda Saraç.
Bahçeşehir University, Istanbul, Turkey.
E-mail: seda.sarac@es.bau.edu.tr
ORCID: http://orcid.org/0000-0002-4598-4029

[b] Betül Tarhan.
University of Georgia, Georgia, USA.
E-mail: tarhan@uga.edu
ORCID: http://orcid.org/0000-0002-6339-1876

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Abstract

Throughout preschool years, young children achieve important gains in terms of self-regulated learning (SRL) development. Recent research highlights the importance of the role preschool teachers in promoting SRL skills. However, several factors affect teachers' level of support in the classroom. The aim of this study was to investigate the frequency of preschool teachers' practices to promote SRL. Also, contextual (class size and children's age) and teacher-level (year of experience and teaching self-efficacy) factors affecting their practices were investigated. The study sample consisted of 210 Turkish preschool teachers. Data were obtained via self-report measures. The participants reported that they frequently implement practices that support self-regulated learning. However, they allocated the least time on children's retrospective task reflections. Novice teachers reported more frequent SRL promotion than experienced teachers. The amount of SRL practices was affected by the class size. Teachers with more than 15 children reported less frequent SRL promotion. Also, more SRL promotion reported by teachers of older children (61-72 month olds) compared to younger children (48-60 month olds). Teacher self-efficacy was a strong predictor of teachers' SRL promotion.

Keywords:
Early Childhood, Preschool Teachers, Self- Efficacy, Self-Regulated Learning, Self-Regulation

Introduction

The goal in educational institutions is to take a stance that will enable individuals to reach and access information on their own instead of teaching that knowledge. In this context, what needs to be done is to teach learner how to learn (Kocaman & Osam, 2000). Teaching how to learn is to make learners self-regulated learners. Self-regulation in learning refers to the ability of an individual to manage his/her learning behaviours according to their aims (Wolters, 2003). It is a self-directed process in which learners transform their mental abilities into skills (Zimmerman, et al. 1996) and habits through a developmental process (Butler, 1998) emerging from guided practice and feedback (Paris & Paris, 2001). In the process of self-regulated learning (SRL), learners set goals for themselves and take an active role in their learning by monitoring and controlling their cognitive processes,

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motivational levels, and behaviours (Pintrich, 2000; Zimmerman & Schunk, 2011). Self-regulated learners can manage their learning behaviours towards their goals and have a broad repertoire of strategies that enable them to do so (Wolters, 2003).

Self-Regulated Learning

Several researchers developed models to explain SRL (Boekaerts & Cascallar, 2006; Efklides, 2011; Winne, 1996; Zimmerman, 2000). However, these models were generally developed through studies conducted with school students and university students. Thus, current study was built on the analytic model used by Whitebread, et al. (2009) for young children and which, also, formed the theoretical basis of the T-SRL scale used in the study (Adagideli, et al., 2015). According to Whitebread, et al. (2009), SRL consists of three sub-dimensions; metacognitive knowledge, metacognitive regulation, and motivational-emotional regulation. Metacognitive knowledge pertains to the accumulated knowledge of the individual related to cognitive behaviours, goals, tasks and strategies (Flavell, 1979). There are three types of metacognitive knowledge, namely; knowledge of person, task variables, and strategy variables (Flavell, 1979; 2000). Examples of metacognitive knowledge would be knowing that mentally repeating a shopping list will be helpful in remembering or starting with the largest puzzle piece will make it easier to complete the puzzle (Marilus, et al., 2016). Metacognitive regulation refers to skills used to orchestrate cognitive behaviours while learning (Efklides, 2008; Schraw, 1998). These activities are related to individual's decisions about what, when, why, and how to act in case of a problem in monitoring and evaluating their own actions, progress, plans, and outcomes (Schraw & Moshman, 1995). Regulatory skills can further be classified under four subcomponents; planning, monitoring, control, and evaluation (Meijer, et al. 2006; Schraw, et al., 2006). Planning, as an important dimension of behaviour regulation and cognition, includes determining the goals that will guide cognition and understanding in general and metacognitive monitoring in particular and the selection of appropriate strategies in line with these goals (Meijer, et al., 2006; Pintrich, et al., 2000; Pressley, 2000). Monitoring is an assessment of the current situation or ongoing progress of a particular cognitive activity (Dunlosky & Metcalfe, 2009). In this way, individuals can decide, for example, whether they fully memorize the multiplication table or whether they understand the text they just read. Control refers to conscious or unconscious decisions made based on the information obtained as a result of monitoring. These decisions may cause a cognitive activity to start, continue, stop, or change the implemented strategy (Dunlosky & Metcalfe, 2009; Nelson & Narens, 1994). Evaluation involves judging the individual's own learning outcomes and regulatory processes with respect to task performance. Evaluating the individual's learning goals, reviewing their predictions, and combining and consolidating their cognitive gains from the task are typical evaluation activities performed during and/or after the task performance (Schraw, et al., 2006; Schraw & Moshman, 1995). Motivational-emotional regulation is learners' monitoring and controlling of their emotions and motivational states during learning to focus attention and persist in the learning task (Boekaerts, 1999; Corno, 2001).

Promoting Self-Regulated Learning in Preschool Years
The early signs of SRL skills begin in preschool years (Bronson, 2000; Larkin, 2006). Studies showed that preschool children possess metacognitive knowledge about person, task and strategy variables affecting their cognitive performance (Marilus, et al. 2016; Shamir, et al. 2009). They are also able to make plans (Adagideli & Ader, 2017; Hendrey, et al., 2016; Jacob, et al, 2019), monitor (Marazita & Merrima, 2004) and control their own learning processes (Dörr & Perels, 2019a; Jacob, et al, 2019; Robson, 2010) and evaluate and reflect on their learning (Perry & VandeKamp, 2000; Zelazo, 2015). Young children also can regulate their emotions and motivations to initiate, plan and persist on learning tasks (Whitebread, et al., 2005).,

Early childhood education has a very important role in the development of children. The first years when children enter into educational system are also the years when their attitudes toward education and perception of self-efficacy begin to develop (Whitebread, 2000). Mistakes made in instructional processes during these years cause children to develop ineffective and undesirable–even harmful–learning habits and behaviours (Dignath & Büttner, 2008; Dignath, et al., 2008; Perels & Otto, 2009; Perry, et al., 2004), and these habits and behaviours have negative effects on children's future academic achievement. In the same vein, Larkin (2009) attaches importance to promoting SRL skills that are required to cope with the challenging tasks for achieving in school. According to Baron (2015), even minor self-regulatory skill differences among preschool children in this period emerge as large differences in a child's academic success over time. Therefore, early SRL support has a preventive aspect in the long term (Venitz & Perels, 2019a).

Several intervention studies reported gains in young children's SRL when supported by the teachers (Dörr & Perels, 2019b; Perels, et al. 2008;). Findings mostly obtained from observational studies revealed that in the learning environments where; activities were child-centred (Stipek, et al. 1995), complex tasks were presented (Perry & Vandekamp, 2000; Whitebread, et al. 2009), children were allowed to choose the difficulty level of the tasks (Perry & Vandekamp, 2008), the assessments were non-threatening (Perry & Vandekamp, 2000), opportunities for peer and small group work activities were presented, child-initiated, independent activities were supported (Nietzel & Connor, 2017; Whitebread, et al., 2009), children were encouraged to articulate their thinking processes (Whitebread & Coltman, 2010) and a warm teacher-child relationship were established (Perry, 1998; Perry & Vandekamp, 2008; Whitebread & Coltman, 2010).

As the above-mentioned studies revealed, the way teaching-learning processes are designed is key to the development of children's SRL skills. In this regard, the teacher, as the regulator of learning environment and teaching-learning processes, has a primary role (Venitz & Perels, 2019b). Instead of the teacher-centred, teacher-directed teaching and learning environments in which teachers assume the control, teachers should create such environments in which children feel they are in control and allowed to make decisions about their own learning (Kistner, et al., 2010; Perry & Vandekamp, 2009).

Teacher-Level Factors Affecting Teachers' Promotion of Self-Regulated Learning

Teachers play a key role in promoting self-regulation skills (Peeters, et al., 206). In studies with primary school teachers, teacher-level variables appeared to be the most important factors affecting teachers' promotion of SRL in their classrooms (Lombaerts, et al. 2009; Thomas, et al., 2020). Teachers' beliefs and teaching experience were the prominent factors in SRL practices (Lombaerts, et al., 2007, Moos & Ringdal, 2012).

There are several studies examining the level of primary and secondary school teachers' support of SRL and the factors affecting their level of support. Among the factors that affect teachers' support of SRL in primary schools, one particular teacher characteristic, namely teachers' self-efficacy beliefs, was consistently found to be a significant factor affecting teachers' practices that promote SRL (Chatzistamatiou, et al. 2013; Dignath-van Ewijk, 2016; Lombaerts, et al., 2009; Vandevelde, et al., 2013; Tanrıseven, 2013). Self-efficacy belief is the self-judgment of individuals about their capacity to plan and accomplish the required activities for performance in a specific subject (Bandura, 1997). The perception of teachers' self-efficacy is their self-belief in establishing a successful learning environment (Goddard, et al., 2004). For Bandura (1993), teacher's beliefs in their self-efficacy in enhancing learning and learner-motivation in the classroom affect the characteristics of the learning environment they create in the classroom, and, thus, the learners' achievement (Bandura, 1993). Studies showed that teachers who perceive themselves to be self-effective make more effort for teaching, become more open to new ideas that can contribute to their students' learning, and leave more room for innovative practices (Tschannen-Moran, et al., 1998). Fantuzzo, et al. (2012) showed that the preschool teachers with higher self-efficacy beliefs spend more time on cognitive and socio-affective learning in their classrooms. Furthermore, Perren, et al. (2017) concluded that preschool teachers with higher self-efficacy beliefs are more successful in creating child-centred learning environments that effectively support children's learning and development by taking into account the children's individual and developmental levels. As for SRL, no studies have investigated the effect of preschool teachers' self-efficacy beliefs on their SRL practices so far.

Another important teacher-level variable that may affect teachers' promotion of SRL may be the seniority of the teachers. As mentioned above, less controlling environments are recommended for the development of SRL of preschool children, According to Martin, et al. (2006) experienced teachers were more competent in establishing classroom routines than novice teachers and they display less controlling behaviours in the classroom. Zembat and Yılmaz (2018) investigated the effect of teacher seniority on preschool teacher practices promoting SRL in the classroom and consistent with Martin, et al. (2006), teachers with more than 11 years of teaching experiences reported more frequent use of SRL practices than teachers' with less experience.

Contextual Factors Affecting Teachers' Promotion of Self-Regulated Learning

Researchers call for studies to identify the contextual factors that cause differences in teachers' SRL support practices (Muijs, et al., 2014). One contextual factor that may impact teachers' self-regulated support is the class size. Although there are no studies on whether the classroom size affects teachers' SRL support in early childhood classrooms, there are studies showing that the class size affects the quality of teaching. In their literature review Francis, & Barnett (2019) review pointed out that classroom size was important in early childhood education and that reducing the number of children by 5 had a positive effect on the quality of teaching and increases the success of children in the classroom. Similary, Le, et al. (2015) study evidenced a threshold at about 15 children per classroom. When the number of students exceeded over 15, it decreased the teacher-student interaction and thus the observed quality of teaching.

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Another contextual factor, age of the children, may affect teachers' SRL practices in the early years. No study investigating whether there is a difference between age groups in terms of teachers' SRL support in the preschool period was found. However, it can be expected that there will be more support for SRL in pre-primary group compared to younger age groups, as pre-primary curriculum concentrates more on academic skills (MoNE, 2013).

Purpose of the Study

Although studies on self-regulated learning are not new, research in this field is mostly conducted at primary, secondary, and tertiary levels. Studies on preschool children started in the 2000s only. This delay is largely due to a common assumption that metacognition as the cognitive dimension of SRL is only beginning to develop at around the age of 8-10 (Whitebread, et al., 2009). However, studies using learning tasks that children frequently encounter in daily life and studies conducted by observing children in their natural environment instead of relying on their verbal skills proved earlier emergence of SRL skills than expected (e.g., Annevirta & Vauras, 2006; Larkin, 2006; Perels, et al. 2008; Perry, 1998; Perry & VandeKamp, 2000; Robson, 2010; Whitebread & Coltman, 2010). Although all these findings paved the way for the studies on how to develop these skills, literature on to what extent preschool teachers' support SRL in their classrooms and the factors that affect their support are scarce. Uncovering the factors that affect the SRL support of preschool teachers can shed light on eliminating preventive factors and determining when and how teachers can be supported during pre-service and in-service teacher education and training. To fill this gap, this study aimed to investigate preschool teachers' practices in promoting SRL in their classrooms and the factors affecting their promotion. Following the recommendations of Lombaerts, et al. (2009) this study focused on teacher-level and contextual factors. As for the teacher level factors, the study concentrates on the teachers' year of experience and teaching self-efficacy beliefs. The age of the children in the classroom and the number of children were scrutinized as the contextual factors.

Context of the Study

Preschool education is not compulsory in Turkey. Early childhood education and care (ECEC) services are provided and administered under the Ministry of National Education (MoNE) or Ministry of Family and Social Policies (MoFSP). Institutions serving children up to three years of age operate under the MoFSP, while institutions serving children aged 3-5 operate under the MoNE. MoNE affiliated preschools provide educational services for 36-68 months old children (MoNE, 2014).

As Turkey adopted a centralized educational system, the MoNE determines the preschool curriculum. The preschool education curriculum, last updated in 2013, was developed to ensure healthy development of children through rich learning experiences. The curriculum is versatile with supportive and preventive dimensions. The curriculum aims to support all developmental areas as well as preparing them for primary education and to prevent deficiencies that can be seen in all development areas. (MoNE, 2013).

From the perspective of promoting SRL, there is no clear reference in the curriculum. However, several principles on which the curriculum is based, point to the provision of learning environments that enable the development of SRL skills. It was clearly stated in the curriculum documents that the program is prepared with a child-centred approach and all practices should be strictly performed within this framework Also, the main principles underlying the curriculum puts emphasis on allowing children to learn through experiments, arranging play-based activities, allocating as much time as possible to children's independent play, allocating balanced time for individual, small group, and whole class activities. In addition, the curriculum highlights the importance of building a sensitive, warm and consistent relationship between teacher and child in order for children to realize their potential. (MoNE, 2013) which aligns with findings of Perry and Vandekamp (2008) and Whitebread and Coltman (2010) regarding environments that supported SRL development of young children.

The MoNE (2013) curriculum was organized around three age groups: 36-48 months, 48-60 months, and 61-72 months. Thus, typically, in all the MoNE-affiliated kindergartens, children are divided into classes according to these age groups and receive education within the curricular aims determined for that age group (MoNE, 2014).

According to MoNE (2014), it is essential that the number of children in a group should not be less than 10 and more than 20. If the number of children is higher than this number, a second group should be formed. However, in some cases, due to lack of enough number of teachers, there can be more than 20 children in one class.

Research Questions of the Study

There are four research questions in this study:

1. Do preschool teachers report using practices that support SRL?

2. Do the frequency of teachers' support practices vary according to sub-dimensions of SRL?

3. Do contextual factors (class size and children's age) affect Turkish preschool teachers' promotion of SRL?

4. Do teacher-level factors (years of experience and self-efficacy beliefs) affect Turkish preschool teachers' promotion of SRL?

Method

Subjects of the Study

The participants of the study were preschool teachers from MoNE-affliated preschools in Istanbul, Turkey (*N*= 210). Participation in the study was voluntary. Data obtained via anonymous questionnaires. Informed consent was received with yes / no question before filling the questionnaire. It is stated in the Informed Consent that they can withdraw any time. All the participating teachers were female (100%). The participants' ages ranged between 20 years and over 40 years. In order to become a preschool teacher and to work in MoNE-affliated preschools in Turkey, it is obligatory to have a 4-year bachelor's degree from Faculty of Preschool Teacher Education Candidates take theoretical and practical courses during their four-year undergraduate education. All teacher education programs implement the same curriculum developed by the Higher Education Council. Thus, all participating teachers have at least BA degree in preschool teaching. Some teachers, also, hold an MA degree in preschool teaching (4.8%). All teachers stated that they did not receive formal or informal training in SRL. Teachers either work at kindergarten (4- to 5-year-olds) or pre-primary classes (5- to 6-year-olds). Based on the results of Bivona's (2002) and Martin, et al. (2006) studies, the teachers were divided into two groups according to the number of years they teach, as between 0-10 years (novice) and over 10 years (experienced). Also, in line with the findings of Lee, et al. (2015) and Francis and Barnett (2019) studies class sizes were investigated in three groups as 0-15, 16-20 and 21 and above. Descriptive characteristics of the participant teachers are presented in Table 1.

Measurement Tools

The present study used three tools to collect data.

Personal information form

A personal information form compiled by the researchers was used to collect data on the participants' age, gender, years of experience, the type of institution they work for, the age group they teach, class size.

Teachers' Practices to Promote Self-Regulated Learning Scale (T-SRL)

The T-SRL is a self-report scale developed by Adagideli, et al. (2015) to assess the extent to which preschool teachers promote SRL. The 21-item scale consists of five subscales; namely, metacognitive knowledge of the person (three items), metacognitive knowledge of task and strategy (four items), metacognitive regulation during the task (six items), metacognitive regulation after the task (three items) and emotional and motivational regulation (five items). Table 2 shows sample items from each subscale.

Table 1

Participant Preschool Teachers' Descriptive Characteristics

Groups	*n*	*f*	%
Years of experience	Up to 10 years	145	69.0
	11 years and above	65	31.0
Class size	Up to 15 children (small)	55	26.2
	16-20 children (medium)	105	50.0
	21 children and above (large)	50	23.8
Age of children	Kindergarten (48-60-month-olds)	71	33.8
	Pre-primary (61-72-month-olds)	139	66.2
School type	Public	69	32.9
	Private	141	67.1

Table 2

T-SRL Subscale Sample Items

T-SRL subscale	Sample items
Metacognitive knowledge of person	I provide opportunities for my children to be aware of how they learn.
Metacognitive knowledge of task and strategy	I draw my children's attention to various strategies that they can use for classroom tasks.
Metacognitive regulation during task	I let my children make decisions about how to work
Metacognitive regulation after task	I teach my children how to evaluate their learning
Emotional and motivational regulation	I help my children develop awareness about their emotional reactions while working on tasks.

The items were formulated into statements so teachers could respond on a four-point scale (0= never; 3=always). The internal reliability of the total scale for the original study was .91. The internal reliability of the subscales of the original study were .72 for the metacognitive knowledge of person, .79 for the metacognitive knowledge of task and strategy, .81 for the metacognitive regulation during task, .75 for the metacognitive regulation after task and .84 for the emotional and motivational regulation. For the current study internal reliability for the subscales were .84, .89, .86, .84 and .82, respectively. The internal reliability of the total scale for the current study was .94.

Preschool Teachers' Self -Efficacy Beliefs Scale

The "Single-Dimension Self-Efficacy Beliefs Scale for Preschool Teachers" developed by Tepe and Demir (2012) was used to measure the preschool teachers' self-efficacy beliefs about teaching. The scale, consisting of 37 items, was designed as a five-point Likert scale (0= Not at all; 4= Completely). The scale includes items for the teaching-learning process (e.g. I can ensure the active participation of my students in the learning process), and communication skills (e.g. I can use body language (posture, gestures, eye contact, etc. effectively), family participation (e.g. I can encourage families to participate in school and classroom activities.), planning (e.g. I can plan transitions between activities in a way that does not disturb the flow of the lesson), designing learning environments (e.g. I can organize the learning environment to support my students' creativity., and classroom management (e.g. I can come up with solutions for negative student behaviour), and it is used as single-dimensional with a single total score. The maximum score obtained from the scale was 148, while the minimum score was 0. Higher scores indicate higher teaching self-efficacy. The internal consistency for the original study for the total scale was .97, while the internal reliability of the scale for the current study was .95.

Results

The study investigated preschool teachers' practices in promoting SRL in their classrooms and the factors affecting their promotion. The findings regarding research questions are presented below under their respective headings.

Do preschool teachers report using practices that support SRL?

To find out whether preschool teachers promote SRL in the classroom, first, calculations were made for the minimum and the maximum values, arithmetic means, and standard deviation values for each sub-dimension in the T-SRL. These values are presented in Table 3. As can be seen in Table 1, teachers reported that they frequently included practices that support all sub-dimensions of SRL in their classroom.

Do the frequency of teachers' support practices vary according to different sub- dimensions of SRL?

To find out whether the frequency of support practices vary according to different sub-dimensions of SRL, one-way within-subjects ANOVA was conducted. No outliers have been observed, and data were normally distributed at each time point, as assessed by box plot and the Shapiro-Wilk test ($p > .05$). The findings of Mauchly's test of sphericity revealed that the assumption of sphericity was violated, $\chi^2(2)= 113,074$, $p= .000$, and therefore, a Greenhouse-Geisser correction was used. One-way within-subjects ANOVA with a Greenhouse-Geisser correction showed a statistically significant difference between at least two means ($F[3.127, 653.461]= 13.267$, $p= .000$). Post hoc tests using the Bonferroni correction revealed that only the mean scores for Metacognitive Regulation After Task ($M= 2.504$, $SD= .535$) differed significantly from Metacognitive Knowledge of Person ($M= 2.660$, $SD= .437$), Metacognitive Knowledge of Task and Strategy ($M= 2.671$, $SD= .416$), Metacognitive Regulation

Table 3
Descriptive Statistics of the T-SRL Subscales

Scale	*N*	Min.	Max.	*M*	*Sd.*
Metacognitive knowledge of person	210	1.00	3.00	2.66	.44
Metacognitive knowledge of task and strategy	210	1.75	3.00	2.67	.42
Metacognitive regulation during task	210	1.17	3.00	2.66	.42
Metacognitive regulation after task	210	1.00	3.00	2.50	.40
Emotional and motivational regulation	210	1.80	3.00	2.60	.42
T-SRL Total	210	1.71	3.00	2.62	.36

During Task (*M*= 2.658, *SD*= .419), and Emotional and Motivational Regulation (*M*= 2.598, *SD*= .399). In other words, preschool teachers reported to allocate the least time on children's retrospective task reflections ($p< .001$).

Do contextual factors (class size and children's age) affect preschool teachers' promotion of SRL?

A one-way ANOVA was used to determine whether teachers' SRL practices differ by the class size. Table 4 shows ANOVA results.

One- way ANOVA result with the T-SRL total score showed that the frequency of SRL support varies with the class size. According to Fisher's LSD post hoc results, teachers of large classes reported significantly less SRL support practices in their classes compared to small and medium classes ($p< .05$). When comparisons were made for sub-dimensions, the results showed that, apart from Metacognitive Knowledge of Person, class size is an important determinant of teachers' SRL practices. Fisher's LSD post hoc analyses revealed that there were no statistically significant differences between small (up to 15 children) and medium (16 to 20 children) classes in terms of teachers' support for Metacognitive Knowledge of Task and Strategy, Metacognitive Regulation During Task and Emotional and Motivational Regulation. However, SRL support for these sub-dimensions significantly decreased for large classes (21 and above children) when compared to small and medium classes ($p< .05$). Only for Metacognitive Regulation After Task, teachers of medium classes reported more frequent use of practices compared to small and large classes ($p< .05$).

Considering the age group of the children taught by teachers, independent samples *t*-tests showed no difference among frequency of support for Metacognitive Knowledge of Task and Strategy, Metacognitive Regulation During Task, and Emotional and Motivational Regulation. However, statistically significant differences observed among Metacognitive Knowledge of Person for the kindergarten group (*M*= 2.568, *SD*= 0.427) and the pre-primary group (*MD*= 2.707, *SD*= .437, $t[208]= -2.202$, $p< .05$ and in Metacognitive Regulation After Task for the kindergarten group (*M*= 2.399, *SD*= 0.545) and the pre-primary group (*MD*= 2.559, *SD*= .524), $t[208]= -2.062$, $p< .05$. Pre-primary teachers reported more frequent utilization of practices to support Metacognitive Knowledge of Person and Metacognitive Regulation After Task.

Do teacher-level factors (years of experience and self-efficacy beliefs) affect preschool teachers' promotion of SRL?

Independent samples *t*-tests were used to examine whether preschool teachers' years of experience affect their practices to support SRL. Analysis with the T-SRL total score showed that the frequency of SRL support did not differ according to the teachers' year

Table 4
Results of one-way ANOVA for class size

Measure	Small classes (*n*= 55)		Medium classes (*n*= 105)		Large classes (*n*= 50)		*F* (2,207)
	M	SD	M	SD	M	SD	
Metacognitive knowledge of person	2.66	.45	2.71	.43	2.55	.42	2.147
Metacognitive knowledge of task and strategy	2.75	.38	2.69	.41	2.55	.43	3.490*
Metacognitive regulation during task	2.69	.41	2.71	.37	2.52	.43	4.257*
Metacognitive regulation after task	2.48	.50	2.58	.51	2.35	.60	3.265*
Emotional and motivational regulation	2.65	.41	2.63	.40	2.47	.44	4.257*
T-SRL Total	2.65	.36	2.67	.35	2.49	.36	4.504*

*$p<.05$

Table 5
Results of simple linear regression analyses on predictive effect of self-efficacy beliefs on SRL practices

	R	R^2	*F*	Std. E	*β*	*t* (208)
Metacognitive Knowledge of Person	.483	.234	63.396	.002	.483	7.962*
Metacognitive Knowledge of Task and Strategy	.452	.204	53.435	.002	.452	7.310*
Metacognitive Regulation During Task	.529	.280	80.974	.002	.529	8.999*
Metacognitive Regulation After Task	.561	.315	95.549	.002	.561	9.775*
Emotional and Motivational Regulation	.593	.352	112.997	.002	.593	10.630*
T-SRL Total	.628	.395	135.550	.002	.628	11.643*

of experience. When comparisons are made for sub-dimensions, the results revealed that the frequency of practices to support Metacognitive Knowledge of Person, Metacognitive Knowledge of Task and Strategy, and Metacognitive Regulation After Task does not differ by the teachers' years of experience. However, novice teachers (0-10 years) (*MD*= 2.699, *SD*= .353) support Metacognitive Regulation During Task more than teachers with over 11 years of experience (*MD*= 2.567, *SD*= .478), $t[96.535]= 2.000$, $p< .05$).

Simple linear regressions were calculated to predict the preschool teachers' practices that promote self-regulated learning based on teachers' self-efficacy beliefs. Table 5 shows regression results. The results showed that teachers' self-efficacy scores significantly predicted total SRL practices as well as practices on every sub-dimension. This suggests that 40% of the variation in the T-SRL total scores is explained by teachers' self-efficacy beliefs. For the sub-dimensions, the amount of variance explained varies between 20% and 35%.

Discussion

Important gains in self-regulated learning skills emerge in the early childhood years. In this context, it becomes even more important that preschool teachers create environments that support SRL. Promoting SRL can be possible by creating environments in which children can practice their SRL skills. In this study, the frequency of teachers' practices supporting SRL in the classroom was examined based on the teachers' self-reports. Preschool teachers reported that they frequently implement practices that support children's SRL. The participant teachers had no formal or informal training on how to support SRL. It seems that although teachers do not know or name the strategies they have developed, they intuitively understand their importance and even implement them in their classrooms. However, among all the sub-dimensions of SRL, teachers devote the least time to self-evaluation and peer-evaluation activities. With peer- and self-evaluation practices, students are encouraged to participate in the evaluation process, which is an important part of the self-reflection phase of self-regulation (Zimmerman, 2008). Several researchers highlighted the importance of self-evaluation and peer-evaluation as part of practices that support SRL (Dignath, et al., 2008; Panadero & Alonso-Tapia, 2013; Panadero, et al. 2017; Panadero & Romero, 2014). Consistent with the results of the current study, teachers do not always prefer active involvement of the students in the evaluation (Jonsson, et al., 2015; Panadero, et al., 2016; Spruce & Bol, 2015). Studies with the teachers of older students showed that teachers were concerned about their students' maturity to be objective and truthful in self and peer evaluation (e.g., Noonan & Duncan, 2005). Given that self-evaluation and peer-evaluation activities have an important role in supporting SRL, teachers should be informed about the importance of self- and peer evaluation and supported on how to engage children in evaluations activities in the classroom.

In this study two contextual factors (class size and age of children) were investigated. In terms of the age group of the children (kindergarten vs. pre-primary), teachers of both groups reported that they frequently support for children so that they get to know task types, realize the strategies to be used according to the task type, and monitor and control their cognition, emotions, attention, and motivation. However, the teachers working with older children, i.e. pre-primary reported providing more frequent support for children to acquire information about their cognitive processes (metacognitive knowledge of person) and evaluate their performance (metacognitive regulation after task). Considering that the pre-primary children will start primary school the following year, it's plausible that the teachers are more academic-oriented and, therefore, more concerned with developing children's metacognitive knowledge and evaluation skills.

As for the class size, the number of the students in a class does affect the frequency of teachers' reported support for the students. It seems that having more than 20 students hinders teachers' SRL support. For the effective promotion of SRL skills in preschool independent work, peer work and collaborative work emerge as the most prominent support structures in the classroom (Iiskala, et al., 2004; Perry, et al, 2002; Whitebread at al., 2007). A recent meta-analysis in early childhood education highlighted the importance of small class sizes (Bowne, et al., 2017). According to Almulla (2015) teachers have difficulties in applying effective teaching strategies in large-size classrooms, and they prefer to use teacher-centred teaching strategies instead of learner-centred approaches. Similarly, Blatchford, et al., (2005) posited that teachers in large classes were likely to use whole class teaching, teacher-directed activities, whereas in smaller classes teachers were more prone to utilize group work and were able to give attention and support to each student individually. So, if the aim is to develop self-regulated learners, all necessary precautions should be taken in order for the class sizes to be below 20.

Comparing experienced and novice teachers, the results showed that only the frequency of support on Metacognitive Regulation During Task dimension differs between novice and experienced teachers, i.e. novice teachers appeared to provide students with more information and support to keep track of their learning and ask for help, which can be associated with newly-graduated teachers' more familiarity with the new perspectives on learner-centeredness than their experienced colleagues. This result is consistent with Wilcox-Herzog's study (2002), where more experienced preschool teachers were less sensitive to children's developmental levels which is the basis for promoting SRL in the classrooms. Similarly, Klug, et al., (2015) and Peeters, et al., (2015) reported that more experienced teachers were less likely to support SRL. However, the findings are inconsistent with Zembat and Yılmaz (2018) study. In their study, they used the same scale, i.e. T-SRL, with the current study and they found a significant difference in favour of those teachers with over 11 years of experience on total T-SRL scores. This inconsistency needs further investigation.

With regard to the relationship between the teachers' support for SRL and their self-efficacy beliefs, the level of self-efficacy belief can account for teachers' support to a great extent. Various studies showed that in order to support SRL in the classroom, teachers needed to allow their students to experiment through these skills with more learner-centred activities (Perry & Vandekamp, 2000; Stipek, et al. 1995; Whitebread, et al., 2009). It seems that the higher the teachers' self-efficacy beliefs, the braver they get, and the more room is provided for the activities initiated by the children. The results of the present study are also consistent with the results of the studies conducted with the teachers of older age groups (e.g., Lombaerts, et al., 2009; Tanrıseven, 2013). This result posits that teachers' self-efficacy should be developed by equipping teachers with learner-centred pedagogies through pre-service and in-service training.

Conclusions, Limitations, and Directions for Future Studies

Self-regulated learning skills are considered among the basic requisites of both life-long learning and academic achievement. It is extremely important that teachers support students in taking the responsibility for their own learning, hence help them in becoming self-regulated learners. This study shows that even though preschool teachers do not receive formal training in SRL and how to support it, they intuitively feel the need to support their students' SRL skills. Nevertheless, it is necessary to take this as an educational policy instead of leaving the issue to teachers' instincts or limiting it within rather few things that they learn at school.

This study is important, as this is one of the first studies to examine the SRL practices of preschool teachers according to the sub-dimensions of SRL and try to reveal the contextual and teacher-level factors that affect these practices. However, this study was based on teachers' self-reports. The results obtained should be considered accordingly. In fact, there are observational studies from the Turkish preschool context showing that teachers allocate very limited time for children's independent work that is known to support SRL. For instance, Gol-Guven (2009) studied ECEC classrooms in Turkey to identify quality indicators. She observed that children often engage in whole group, teacher-led activities, and spend a little time for the small group or individual activities. In a more recent study by Varol (2013), it has been observed that preschool teachers generally spend time on teacher-led large group activities. The time allocated for small group activities, which is extremely important for the development of SRL, is only 2%. It has been observed that only 14% of the class time was allocated to play, which also has an important role in the development of SRL. Hence, observations of preschool teachers' actual practices in classroom contexts should be examined by future studies.

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