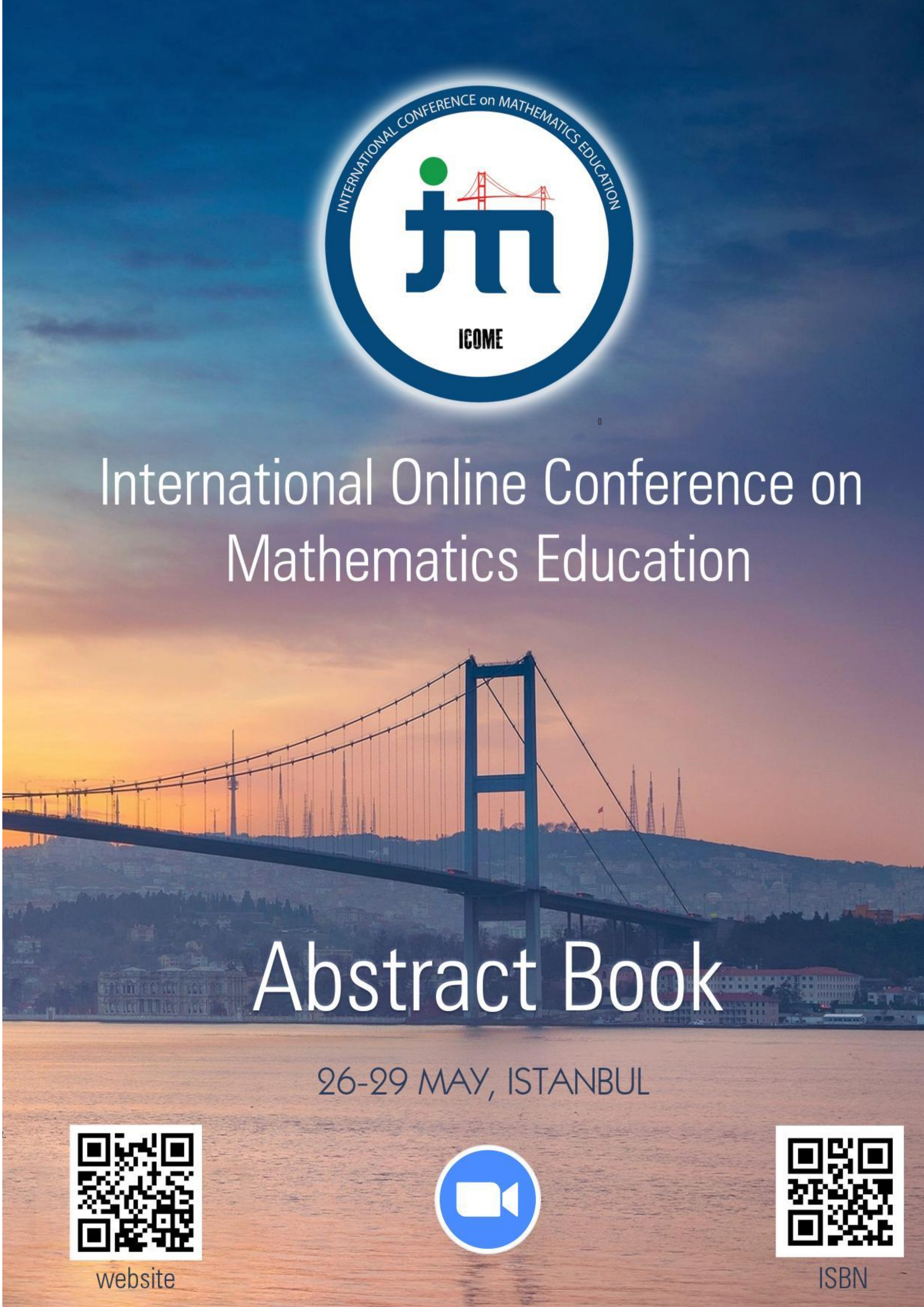

INTERNATIONAL CONFERENCE on MATHEMATICS EDUCATION

ICOME

International Online Conference on Mathematics Education

Abstract Book

26-29 MAY, ISTANBUL

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FOREWORDS

Dear Conference Participant,

Welcome to the International Online Conference on Mathematics Education (ICOME- 2021). Our conferences aim to bring together scientists and young researchers from all over the world and their work on the fields of mathematics education, to exchange ideas, to collaborate, and to add new ideas to mathematics education in a discussion environment. With this interaction; curriculum, assessment, and related topics, mathematical content early/middle/later years, in-service teacher education, professional development, mathematical processes, pre-service teacher education, teaching, and classroom practice, using of technology and the results of applications in the field of Mathematics Education are discussed with our valuable academics, and in mathematical developments both science and young researchers are opened. We are happy to host many prominent experts from different countries who will make presentations from different areas on mathematics education.
However, this year we had to hold our conference online due to the Covid-19 pandemic of the world. The interest and contribution of our participants and audience to the online conference honored us.
I would like to thank first my organization committee members for their efforts in the preparation process and then to all our participants.
Our 2021 conference theme is “A new era and its challenges: Integrating new educational approaches to education.” Despite current difficulties, continuing to make progress by strengthening and developing new educational programs is crucial for every society. Thus, during this critical period of the pandemic, it is important for math educators to discuss the new opportunities, approaches, and challenges that are emerging in the field and how to integrate new educational approaches into mathematics teaching and learning.
The conference brings together participants from 8 different countries and 12 (4 keynote- 8 panelists) invited speakers. More than 50% of our participants will participate in countries different from Turkey. This shows that the conference meets the criteria of being international.
It is also an aim of the conference to encourage opportunities for collaboration and networking between senior academics and graduate students to advance their new perspectives.

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DAY 1 – MAY 26, 2021

KEYNOTE SPEAKER – PROF. DR. ADNAN BAKI

"Social Construction of Mathematical Knowledge"

Prof. Dr. Adnan Baki

Trabzon University, Turkey

(17:00, Turkey) (10:00 AM, Eastern)

PART 1

PARALLEL SESSION 1 (USA EST 11:00-12:00 AM / TR 18:00-19:00)

Determining Preservice Mathematics Teachers' Competence in Proportional Reasoning

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Proportional reasoning has been regarded as a key concept in students' elementary and advanced mathematics (Kilpatrick et al., 2001). Moreover, it has been regarded as a benchmark for students' mathematical competence. Existing studies on proportional reasoning mostly concentrate on the development of students' proportional reasoning and difficulties that they have with this complex concept. Relatively few studies have been conducted with preservice teachers (PSTs). On the other hand, there is a clear need to investigate PSTs' proportional reasoning because determining the knowledge needed for teaching mathematics (e.g., Ball et al., 2008) goes far beyond the understandings students needed (Weiland et al., 2020). However, determining PSTs' competence in proportional reasoning is a very complex task, and existing research methods do not provide effective tools in doing that. Therefore, the purpose of this study is to contribute to the mathematics education literature by proposing an interview structure that uses *in-depth questioning* and *cognitive conflicts* to determine PSTs' competence.
The interview structure is situated in the knowledge-in-pieces (KiP) epistemological perspective (diSessa, 1998). The KiP perspective acknowledges that elements of knowledge are "more diverse and smaller in grain size than those presented in textbooks" (Izsák, 2005, pp. 361-362). These grain-sized elements of the knowledge are referred to as *knowledge resources* that a person draw upon when explaining a situation or an event. Therefore, the interview structure aims at revealing knowledge resources that PSTs draw upon when determining and representing (directly and inversely) proportional and nonproportional relationships. An exploratory multiple-case study methodology was used in designing this study. This study was developed as a part of a research project that investigated 48 first-year

PSTs' (35 female and 13 male) proportional reasoning. During spring semester of 2019, the PSTs were given a paper-pencil test that aimed at collecting their definitions and representations of the directly and inversely proportional relationships. Based the content analysis, semi-structured interviews were conducted with six selected PSTs on two proportion tasks and two graphs to understand their proportional reasoning in more detail. These six PSTs' definitions, representations, and responses to the interview tasks constituted the data sources of the study.

The interview structure was developed by examining the relevant literature on proportional reasoning and having experience in conducting various studies with PSTs. It consisted of three researcher activities (problem posing, in-depth questioning, and providing cognitive conflicts) and PSTs' reactions (working on the problem, inference, reasoning, persistence, justification, refinement, and rationalization) to these activities. During the interviews, I observed the PSTs' tendencies to use rote computations and reliance on certain knowledge resources when determining relationships. The interviews also showed that when those PSTs were provided with some cognitive conflicts that contradicted with their existing understanding of a relationship, they either refined the knowledge resources that they relied on or persisted on using these knowledge resources by rationalizing their incorrect or partially correct understanding. Similarly, in some PSTs, providing cognitive conflicts resulted in their overgeneralization of certain understandings to inappropriate situations.

The empirical study findings showed the PSTs' attention to various knowledge resources. Although initial analysis of the definitions and representations of some PSTs suggested their understanding of proportional relationships, semi-structured interviews indicated that they had difficulty with distinguishing proportional relationships from nonproportional relationships. Therefore, the interview structure was effective in terms of determining the PSTs' competence in proportional reasoning.

Keywords: Knowledge-in-pieces, Knowledge resources, Pre-service teacher education, Proportional reasoning.

Acknowledgment

This work was funded by the Scientific and Technological Research Council of Turkey (TUBITAK).

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Scratch Supported Instructions: Their Effect on 6th Grade Students' Achievements and Attitudes in Algebraic Equations*

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As the technological developments changed people's lives in various fields, the field of education is also influenced by them. There is different software specifically designed for educational purposes. Scratch is among those involving algebraic properties. Considering the properties of this software, teachers can have opportunities to design a learning environment supported with Scratch software for the teaching and the learning algebraic subjects (Rodriguez-Martinez, Gonzalez-Calero, & Saez-Lopez, 2020). It is known that students experience difficulties in understanding algebra due to its abstract nature (NAEP, 2002). Students' learning of algebraic subjects can be improved with Scratch, because it influences students' algorithmic and abstract thinking in positive ways by constructing code blocks. The purpose of this study is to investigate the effect of Scratch supported learning environment on 6th grade students' academic achievements in the subject of algebraic expression and attitudes towards algebra. In addition, opinions of students instructed with Scratch supported implementations were also investigated in this study.

This study utilized mixed method. The participants were composed of 32 students (16 students were in experimental group and 16 were in control group) from a public elementary school at the eastern part of Turkey. Students in experimental group were taught algebraic expressions with the lesson plans involving Scratch activities while curriculum based instructions were implemented to those in control group. Same teacher taught the subjects to the both group. Students were subjected to algebraic expressions achievement test and algebra attitude test before and after the implementations. While the achievement test was developed by the authors, the attitude test was developed by Karaca and Yalçınkaya (2008). The attitude test involves five dimensions, which are interest, behavioral, affective and anxiety. In the qualitative part, students' opinions regarding Scratch supported instructions were gathered. The quantitative data were analyzed with parametric (as if appropriate) or non-parametric tests. On the other hand, the content analysis method was used to analyze the qualitative data gathered with student opinion form.

According to the findings of the study, there was no significant result in students' pre-test scores between the groups. Moreover, Scratch supported instructions influences students' academic achievements and attitudes towards algebra. Comparing the students' scores in post-tests, it was observed that there was a statistically significant results in favor of experimental group instructed with Scratch supported activities. In addition, students perceived the Scratch activities as interesting, joyful and enhancing achievement. Based on the findings, it can be inferred that Scratch supported learning environments can be offered to students in learning other subject in algebra and mathematics.

Keywords: Algebra, Algebraic Expressions, Scratch, Experimental

* This study is derived from the first author's master's thesis.

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The Effects of M-Stem Program on the Scientific Process Skills of Children Attending Montessori Preschool

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Purpose of the Study
This study aims analyzing the effect of the M-STEM program developed for 60-72 months old children attending Montessori preschool on the scientific process skills of children.

Research Questions
1. How does the M-STEM program affect the scientific process skills of children over 60 months old attending a Montessori preschool?
2. Do the effects of the M-STEM program on the scientific process skills of children change depending on the number of years of schooling in a Montessori program?

Theoretical Framework
STEM is a reform of education that enables children to develop the 21st-century skills, required to meet the expectations of the new era (Bybee, 2013). Just as the Industrial Revolution made it necessary for children to learn reading, the technology revolution made it crucial to form a disposition associated with high-quality science, technology, engineering, and math exposure starting with early childhood (McClure et all, 2017). While researchers, policymakers, and educators have stated that STEM should start early to have a more desirable impact, research indicates that early childhood education is the most overlooked field for STEM research and investments (Çorlu, Capraro, & Capraro, 2014). The various objectives of STEM education and the lack of cohesiveness in the nature and scope of integration (Bybee, 2013), suggest further documentation on what integration looks like within a range of settings is necessary (Honey, Pearson, & Schweingruber, 2014). As non-traditional learning environments, Montessori schools are an alternative research area for examining STEM integration, and research in this field is required to bring new perspectives to the topic. Applying insights from STEM education and Montessori to develop an M-STEM program may raise questions capable of both areas of study while addressing corresponding gaps in the existing literature on Montessori schools and early STEM.

Methodology
The research uses a nonequivalent control group design, a quasi-experimental research design consisting of the experimental group and the control group. This is a quasi-experimental design, as the existing groups (classes) were randomly assigned to control and experimental groups. Both groups were given a pretest, posttest, and follow-up test. The dependent variable is the scientific process skills of 60-72 months old children attending Montessori preschool education, while the independent variable is the M-STEM program developed by the researcher. The data gathered with Özkan (2014), "Scientific Process Skills Scale for 60-72 months old children".
This research was conducted at a private Montessori preschool in İstanbul that has AMS (American Montessori Society) Accreditation. 24 children over 60 months participated in the study. For the control group, the M-STEM program was implemented for 10 weeks, 5 days per week, and 2 to 3 hours per day.
As a preschool teacher, AMS accredited Montessori teacher, and a STEM enthusiast who researches thoroughly the subject and took STEM courses from multiple places, I developed the M-STEM program myself, by considering the nature of Montessori and STEM. Before the

implementation of the program expert opinion is provided by two academicians and three Montessori teachers for the M-STEM program.

Results

Regarding the first research question, the scientific process skills pre-test, post-test, and follow-up test results of the experimental and control groups were examined by using the Mann-Whitney U test. According to the results, in the beginning, the Scientific Process Skill levels were no different in the groups, after implementation of the M-STEM program, Scientific Process Skill posttest and follow-up test level of the experimental group was determined to be higher than the control group ($p = 0.04$, $p < 0.05$).

Regarding the second research question, the Spearman correlation test was used for analyzing the relationships of experimental and control group's Scientific Process Skills Pre-Post and Follow-up Tests with Age and Montessori Schooling Year. Results showed that experimental groups' Montessori schooling period and Scientific Process skills pre-test scores were strongly and positively related ($r = 0.65$, $p = 0.03$), while post-test and follow-up test scores were not significantly correlated ($p > 0{,}05$).

Discussion

Results of the study showed that the M-STEM program was effective and permanent for the scientific process skills of children above 60 months old attending Montessori preschool. And the M-STEM program was most effective for children with the first year of schooling in Montessori. It suggests that teachers could use STEM integration in Montessori preschools to enhance children's scientific process skills, especially for those who attended the school later than their peers.

Conclusion

To conclude, Montessori and STEM integration in the preschool was effective to increase children's scientific process skills, and it is suggested to use more in Montessori environments to explore how STEM complement Montessori education in different aspects.

Keywords: *STEM, Montessori, Preschool, Scientific Process Skills*

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PART 1

PARALLEL SESSION 2 (USA EST 11:00-12:00 AM / TR 18:00-19:00)

Investigation of Preservice Elementary and Middle School Mathematics Teachers' Problem Posing Skills on Fractions

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It is necessary to pose problems appropriate to the cognitive level of the students to contribute to their problem solving skills and improve students' creativity. Therefore, it would be more appropriate to pose the problems for this purpose, rather than randomly asking them. Since mathematics is used as a tool in solving problems and sometimes use of natural numbers are insufficient in daily life situations, there is a need for utilization of fractions to complete some of the mathematical calculations. Therefore, posing the appropriate problems for the subject of operations with fractions, which can be used frequently in daily life problems, can help improve the cognitive level of students and create a more effective and permanent learning environment. The main purpose of this study is to determine how preservice elementary and middle school mathematics teachers pose problems about the learning outcome of fractions. Moreover, the study also sought to explore what kind of errors they made in the process of posing problems. This study, designed with the qualitative research model and carried out in the 2019-2020 academic year with the participation of 101 preservice elementary teachers and 55 preservice middle school mathematics teachers. For the purpose of analyzing the qualitative data, the content analysis method was used to determine the errors made during the problem posing process. Content analysis of the problems posed by preservice elementary and middle school mathematics teachers were analyzed independently by researchers who are experts in elementary and middle school mathematics education. As a result of the content review, three categories were formed and compatibility between researchers was found as .953. As a result of the analysis, it was observed that both preservice elementary and middle school mathematics teachers could pose problems in accordance with the knowledge and cognitive process dimension of the learning outcomes; however, they also displayed some errors in this process. The errors made were grouped into three categories as "non-outcome problems", "limitations in field knowledge" and "limitations in problem posing". Moreover, it was noticed that some preservice teachers were displayed inadequate subject matter knowledge while posing problems related to the fractions. As stated in the literature, difficulties in understanding and interpreting the fraction concept may cause some errors in terms of mathematical knowledge in the problem posing process (Davis, 2003; Hasemann, 1981). Although the preparation of the outcomes for educational action intended to be taught is seen as the most basic and important criterion (Kennedy, 2006; Kuzu et. al., 2019; Öçal, 2017); in this study, it was observed that preservice teachers posed the problems associated with different educational purpose other than the intended educational purpose in the learning outcomes. In this context, it becomes clear that careful consideration of educational goals within learning outcomes while posing problems is very important for supporting preservice teachers during learning and teaching processes of mathematics.

Keywords: cognitive process, fraction, problem posing

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Possibilities and Constraints of History of Mathematics for Cultural Diversity

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History of mathematics [HOM] in teacher education can provide historical background for mathematics, promote pedagogical reflection on mathematics and improve attitudes for teaching mathematics (Furinghetti, 2007). HOM is also a promising space to engage with the cultural dimension of mathematics (Guilllemette, 2018). HOM can build a cultural understanding of the subject (Furinghetti, 2007), bring an awareness of the humanistic side of mathematics (Fauvel, 1991) and enable a consideration of mathematics as evolving body of knowledge rather than irrefutable truths (Barbin, 2002). Opening a chapter for cultural diversity in HOM is important as the research confirms the need to recognize the contributions of non-European groups to mathematics, which is often portrayed as an achievement of selected groups of people (Ju, et. al., 2016).

HOM with a sense of cultural diversity conceives mathematics "not just a text" but a lively subject that circulates in the human produced artifacts (Grugnetti & Rogers, 2002). It becomes a way to humanize mathematics, attached to real circumstances, including what humans are doing, making and thinking (Fried, 2001). This can open up possibilities to compare and to recognize diverse ways of knowing and doing mathematics (Grugnetti & Rogers, 2002). As research rarely investigates these issues related to cultural diversity in the context of HOM (Baki & Bütüner, 2018), following research question is asked:

- What are the potentials and limitations of the emphasis on cultural diversity in the context of a HOM course for prospective mathematics teachers [PMTs]?

Participants were 12 PMTs enrolled in an elective HOM course at a large research university in Turkey. The course provided an account of histories of mathematical work through representing the ways in which various civilizations engaged in different cultures and geographies. Data source was the face-to-face interviews, asking how PMTs made meaning of the existence of diverse civilizations and epistemologies throughout mathematics history. After transcriptions, the instances that PMTs talked about issues that relate culture, diversity and humanity in the context of historical development of mathematical knowledge were coded with inductive qualitative methods (Corbin & Strauss, 2008).

PMTs studied the diverse civilizations in HOM and they generally affirmed the existence of diverse mathematical needs that were specific to each culture. They could discuss the historical-cultural conditions for mathematical knowledge development and involvement of humans. According to results, mathematical needs emerged as a way to acknowledge the role of humans through history. For several PMTs, historical development of mathematical knowledge was situated in a specific context and it was shaped by needs of daily life in particular period and culture. For example, PMT8 stated that: "Actually, some of them tried to do something as a result of their needs. And in different places, everyone did something according to the situations they encountered, depending on their culture and environment."

While PMTs considered mathematical needs of daily life as a way to reflect upon the cultural diversity in HOM, needs were also ranked on a hierarchical continuum. Mathematics, at first, was used to respond to daily life needs such as food, agriculture or water sewing. Provided that humans fulfill daily life needs, PMTs considered them as capable of doing mathematics for science. Several PMTs prompted the idea that diverse needs were to distinguish the kinds of mathematics in which specific civilizations were engaged. In these accounts, HOM was not an equal platform to understand cultural particularities of producing mathematics but rather a differentiated space.

Recognition of diverse needs throughout the history becomes a way to affirm the cultural diversity in HOM and recognize the humanistic aspects of mathematical knowledge.

However, PMTs also compare mathematical needs in a context where intellectual needs could emerge if survival needs were met. This logic becomes a way to position diverse cultures on a hierarchical continuum and confirms Grugnetti and Rogers' (2002) argument, indicating that cultural dimension of HOM cannot put everyone in equal position. Needs as an affirmation of cultural diversity and as an instrument to rank different civilizations suggest bringing both equity and diversity issues together. The implication is the necessity to study and learn HOM with larger social and colonial debates, concerning how relations of power play out in the knowledge making process across the history.

Keywords: History of mathematics, cultural diversity, preservice teacher education, mathematical needs

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Elicit and Use Evidence of Student Thinking and Pose Purposeful Questions

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Purpose of the study

Every teacher should reflect on their own teaching and learning continuously, but it is hard to do without any structure or process with willingness. As an instructor in college, I am eager to improve and develop my teaching skills by doing self-study, so I designed my own self-study. I conducted this study in order to give perspective for trying to do self-study for preservice or in-service teachers.

Research Questions

1. How instructor elicit and use the evidence of student thinking?
2. How instructor pose purposeful questions for students to think about them?

Theoretical framework or perspectives

In the self-study, theoretical framework is the domains of mathematical knowledge for teaching. Among six domains, this study focused on Knowledge of Content and Students (KCS) and Knowledge of Content and Teaching (KCT) (Ball et al., 2008). To evaluate KCS, this study focused on what teachers do to elicit and use the evidence of student thinking (Arbaugh et al., 2019; The National Council of Teachers of Mathematics [NCTM], 2014) To evaluate this domain, the study focused on posing purposeful questions for guiding students' learning (Dupree & Vanlngen, 2016; NCTM, 2014).

Methodology

In order to record the class, researcher used zoom recording for every class time in some students come to zoom class. Additionally, researcher used one more camera to record room to see the students' engagement as well as instductor's feedback towards students.

To analyze the data, researcher made the recording video transcript in two aspects: (1) Elicit and Use the Evidence of Student Thinking, (2) Pose Purposeful Questions. Observers' comments were involved in analyzing to find evidence related to the both aspects.

Results

For the first research question, I could observe positive points such as having knowledge of students' struggling points within the contents and providing various ways of solving the same problem to promote students' mathematical reasoning and thinking. However, I observed that I uncovered students' thinking during class by summarizing some contents without checking their understanding.

For the second research question, as positive actions, I asked students for the reasoning or thinking process rather than specific answers. Also, I asked them to draw pictures as a representation of the contents. As a negative action, I did not give sufficient time to think of the questions and quickly answered them by myself.

Conclusion

First, self-study design is the important component for self-study. Researcher should make more detail plan with to-do list ahead of the class as well as written lesson plan with the problem of practice. In other words, in this self-study, researcher should include questionnaire problems with the specific to-do list in lesson plan.

Second, researcher should focus on only one perspective per a lesson. Teachers could have a passion to develop their teaching in all aspects. However, it is not efficient way but time consuming. Self-study should be continued as long as they teach. Instructors need to develop their teaching but it is not in a hurry. If instructors would like to fix all their problems at once, it is not possible. They should conduct self-study with patience because it took time and effort.

Third, self-study's feedback can make a big improvement in the following classes. In the class I recorded, my critical friend gave me the feedback that I did not give enough time for students to think about reasoning and I quickly gave correct answer. It means students lost the opportunity to elicit their mathematical thinking and firm their knowledge with the contents. However, in the following class which dealt with the same contents for different students, I tried to give enough time to think for my students and tried to make more interaction. In the class, the coordinator attended the class to assess my teaching. After all, she gave me totally opposite feedback of the critical friend. She mentioned I had good manner to interact with proper speed for my students. I could see effect of my self-study through this experience.

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PARALLEL SESSION 3 (USA EST 11:00-12:00 AM / TR 18:00-19:00)

Examining the Flipped Learning Approach and Their Usage Levels in Recognition of Web 2.0 Tools of Faculty Members in Distance Education Process

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The aim of this study is to reveal the level of recognition and use of Web 2.0 tools used to facilitate the flipped learning approach and teaching methods, which are becoming widespread in distance education processes today. The following research questions were sought in the study: What information do lecturers have about the flipped learning approach to learning? In the distance education processes of lecturers; applying the flipped learning approach; Their own competencies in this area, as well as their knowledge of Web 2.0 tools, and how and for what purpose and how they effectively use them in their lessons were investigated. Covid19 Pandemic in Turkey as a result of the pandemic in other countries has also been necessary to distance education distance education process instead of face to face training. In this context, it is important to examine in detail the situation in the distance education process of the lecturers at universities about the flipped learning approach widely adopted in distance education processes and the Web 2.0 tools used. This research is a mixed method research in which quantitative and qualitative research methods are used together. In the quantitative phase of the research, the scanning model was adopted, and the case study method was adopted in the qualitative phase. In the quantitative dimension of the study, a sample of 58 mathematics educators was determined using the probabilistic sampling method. The participants of the qualitative dimension of the sample consist of 6 mathematics educators selected by purposeful sampling method among the mathematics educators in the study group formed in the quantitative dimension. The data of the research were collected online via google forms and via e-mail due to the Covid-19 pandemic process. Qualitative data were collected with a questionnaire form prepared by the researchers and consisting of 8 open-ended questions. It has been analyzed using themes and codes. Findings are presented by frequency and direct quotations. They stated that the lecturers tried to use the inverted teaching method, but they could not get enough efficiency because their class sizes were crowded, and they used most of the web2.0 tools very effectively in their lessons. They also stated that their students were willing to use web2.0 tools.

Keywords: Flipped learning, Web 2.0 tools, Distance education, Mathematics education, Instructors.

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Individual Work as One of the Forms of Development of Cognitive Activity of Students

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The ability to replenish their knowledge, to properly plan cognitive work is very important for any student.

In the process of individual activity, such valuable personality traits as attentiveness, perseverance, accuracy, responsibility are developed.

The essence of individual activity does not lie in the fact that the student ceases to need the teacher's help, and in the fact that the content of the goal of the activity coincides with the goal of managing this activity. There are various classifications of individual works: reproducing, heuristic, creative.

In accordance with the task assigned to them, individual work is training, controlling:
Depending on the location, individual work can be classroom and homework;
By the way, of organization there are collective, individual and group.

Of great interest to students is creative individual work that presupposes a high level of independence. Tasks of a creative nature include solving problems in several ways, drawing up problems and examples by the students themselves, writing essays, etc.

Individual work allows students the formation of self-control over the activities.

Keywords: independence, the essence of individual activity, types of individual work.

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Applicability Of Online Education İn Mathematics Lessons And Students' Attitude During The Pandemic Process

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The corona-virus, which started in November 2019 and started to be seen in our country in March 2020, has affected the whole world. In these processes, many measures were taken in the name of education, and social distance was also tried to be maintained by starting training online. In this study, the applicability of mathematics in online education given during the corona-virus (covid-19) epidemic was investigated, the attitude of students towards online education was examined and some results were obtained to improve its applicability. Unfortunately, the corona virus epidemic has negatively affected human life. Due to the epidemic, schools have been closed for a while and, online education has been started to ensure that education is not interrupted. In this way, deficiencies, inadequacies and some problems in online education have also emerged. In the related study, suggestions were made on how to do distance education in a better way.

Keywords: Online Education, Covid-19, Coronavirus, Math Education

Purpose of the Study and Research Question(s)

During the pandemic process, the importance and even the necessity of online education have come to the fore. Considering this, the following question was asked: "What are the attitudes of students towards online lessons before and after the pandemic?" In this study, Turkey Situated in different provinces, and by me math education students in the 8-14 age group who have also been evaluated responses to questions about the issue. Based on the findings, recommendations for future researchers in this field are presented.

Theoretical Framework or Perspectives

Online education, first mentioned in the 1892 Catalog of the University of Wisconsin, was used for the first time in an article written in 1906 by William Lighty, the director of the same university. Later, this term (Fernunterricht) was introduced by the German educator Otto Peters in the 1960s and 1970s in Germany and applied as a name (Teleenseignement) to distance education institutions in France. (KIRIK, A. (2014).

Preliminary Results

I. Students and parents should be informed about online education.
II. Questions and answers should be made with the students regarding online education.
III. Any questions that students have in mind about online education should be answered a certain time before starting the lessons.
IV. Psychological support should be provided to students and parents in online trainings conducted with the pandemic process.
V. As mentioned in the related study, online education has many advantages. Teachers should be made aware of this issue and lessons should be made more efficient.
VI. Technical features such as screen sharing, smart board and file sharing should be provided. In this way, the use of technologies makes the lessons more efficient, interactive and useful for both students and teachers.

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PARALLEL SESSION 1 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

Pre Service Teachers' Engagement in Mathematical Representations of Social (In)Justice and Inequity

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With acknowledgement to the role that preservice teachers (PSTs)' have in the future of mathematics education, we sought to investigate their ways of interpreting mathematical representations to address the topics of social inequities and injustices. The purpose of this study is to describe PSTs' perspectives toward equity and diversity, especially related to their understanding of systemic inequity and potential calls for action when they interpret mathematical representations. Our research question is "How do preservice teachers incorporate issues of equity and social justice into their mathematical interpretations?"
Based on Gutstein (2006, 2016)'s theoretical conceptualization of reading and writing the world with mathematics, a task for PSTs was developed with the goal of engaging them in reading and writing the world with graphical representations. 54 K-12 PSTs at two universities were asked to choose or find equity-related graphs, conduct research on the topic of the graph, and write an article that included (a) an explanation of why the graph is important in education and an argument convincing readers of the importance, (b) an accurate interpretation of the graph, and (c) the conclusion of the article with the main points related to the theme, equity in education. Data includes 54 PSTs' written articles that reveal their understanding of equity and justice issues through their interpretations of mathematical representations of their choice.
Using analytical-inductive methods (Strauss & Corbin, 1998) and driven by Gutstein (2006; 2016)'s framework, we analyzed PSTs' individual write-up through both pre-determined categories and data-driven categories (open-coding). For example, with the framework in mind, each researcher coded each line of PST's write-ups and gave their own interpretation of each sentence with the possibility of creating new categories driven from the data. Through multiple discussions among the authors, the domains, categories, definitions, and examples were refined and established. The initial categorizations of coders were then reevaluated with consultation of the codebook and consensus was met with collaboration.

Our preliminary results reveal diverse perspectives from the PSTs regarding equity and mathematical interpretations. In many cases, PSTs were forward-thinking and expressed methods in which to address social inequities and injustices. In some instances, PSTs used language that disregarded the identities of diverse groups or does not respectfully address a certain group. We also noticed that some PSTs used mathematics to push equity forward by describing the advantages of the use of selected graphs to educate students on issues of inequity and/or social injustice. The evidence suggests that most PSTs are able to recognize social justice and equity issues found in graphs, however, some are unable to explain or bring awareness to such topics through the use of these mathematical representations to support their claims. Overall, the PSTs have limited understandings of social justice and equity which impacted their interpretations of the graph and conclusions based on those interpretations. In a society that employs teachers to educate students on issues of social injustices and inequities, it is important for these educators to be knowledgeable on these topics; and our study proposes an approach to explore PSTs' understanding of these issues connected to mathematical representations.

Keywords: Preservice teacher education, mathematical representations, equity, social justice

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Developing Preservice Teachers’ Algebraic Reasoning Through Pattern Generalization Activities

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To promote pre-service teachers’ algebraic reasoning and understanding of algebraic symbols/notations, a four-week unit providing a series of pattern generalization activities using color tiles was developed and implemented in a mathematics content knowledge course. Data were analyzed based on an inductive content analysis approach.

Keywords: Pattern generalization, Algebraic reasoning, Preservice teachers

Algebra is a critical subject for students’ continued advancement in mathematics as well their future educational and economic opportunities (National Mathematics Advisory Panel, 2008). Nevertheless, students are often hindered from acquiring the conceptual understanding they need to progress beyond memorizing rules and applying procedures, often because of their teachers’ limited understanding (Kieran, 2007). Accordingly, mathematics teacher educators place priority on producing teachers who have deep conceptual understanding of algebra as well as the pedagogical knowledge for developing students’ conceptual understanding. Preservice teachers (PSTs) often struggle with algebraic reasoning and identifying the interconnectedness of symbols, equations, tables, and graphs (Walkowiak, 2014).

The purpose of the study is to design and implement a unit to promote PSTs’ algebraic reasoning and understanding of algebraic symbols/notations, involving a series of pattern generalization activities using manipulatives, and measure its effects on PSTs’ understanding of algebraic symbols. The research question was as follows: How and to what extent may PSTs’ understanding of algebraic symbols assist in their development of algebraic reasoning regarding equations or functions after engaging in pattern generalization activities using multiple representations involving manipulatives?

The theoretical framework of this study was a quantitative approach (Thompson 1993; Smith & Thompson, 2008), which emphasizes operating with quantities and their relationships behind the algebraic symbols. Quantitative reasoning begins with conceptualizing situations and moving onto reasoning about quantities, their properties, and relationships among quantities before linking the quantitative relationships to numerical operations. Smith and Thompson (2008) highlighted the quantitative reasoning in that it provides conceptual foundation for powerful forms of symbolic manipulations in algebra.

The participants were 49 junior or senior PSTs enrolled in a mathematics content course at a large state university. Data comprised PSTs’ pre- and post-test related to pattern generalization, and an open-ended survey about color tile activities. Both qualitative and quantitative analyses were conducted based on an inductive content analysis approach (Grbich, 2007). Preliminary results of pre- and post-tests showed that the applied unit was effective in improving PSTs’ algebraic reasoning with pattern generalization. Also, in the survey, many PSTs commented that (1) the color tile activities helped them understand how to form an algebraic equation to represent the quantitative changes with visuals and (2) the experience of converting one type of representations to other types strengthened their algebraic understanding. This study suggests a critical role of using multiple representations in deepening PSTs’ algebraic reasoning.

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Developing the an Estimation Skills Self-Efficacy Scale: Validity and Reliability

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Estimation is a concept that is constantly used both in daily life and in scientific studies, and it is not a random action. It is a skill developed as a result of experiences gained in mathematics. Estimation term; It refers to find out the most appropriate approximate value that can be substituted for an exact number corresponding to a certain context alone. Reys and Bestgen (1981) defined estimation as finding the approximate outcome of an operation or problem based on mental calculation. In the literature, it has been observed that there are studies aimed at determining the estimation skills of primary and secondary school students regarding estimation skills (Aytekin&Uçar, 2014 ; Baroody&Gatzke, 1991 ; Bobis, 1991 ; Boz&Bulut, 2012; Crites, 1992; Çilingir&Türnüklü, 2009; Dowker, 1997 ; Hanson&Hogan, 2000 ; Kılıç&Olkun, 2013; Luwel&Verschaffel, 2008; Pilten&Yener, 2009 ; Star Rittle,Lynch&Perova, 2009; Tekinkır, 2008;Yazgan, Bintaş&Altun, 2002), determining the estimation skills of teacher candidates(BozveBulut, 2002; Goodman, 1991;Sulak, 2008;Özcan,2015) and determining the estimation skills of mathematics teachers(Dowker, 1992). The results of these studies revealed that the estimation skill levels of the participants were low. The low estimation skill levels of the students requires revealing their self-efficacy beliefs about the subjects that require estimation skills. This is a quantitative study to develop a valid and reliable scale in order to determine estimation skills self-efficacy of middle school students' and to investigate the estimation skill of middle school students in terms of various variables by means of the developed scale. In this context, the study was conducted on 327 middle school students. In the development process of the scale, exploratory factor analysis, confirmatory factor analysis and Cronbach Alpha internal consistency coefficient and Guttman Split Half values reliability calculations were performed. As a result of the analysis, the total variance percentage of the 29 items, which was composed of five factors, is 55.61%.The model obtained as a result of confirmatory factor analysis is acceptable. The Cronbach Alpha internal consistency coefficient for the whole scale is .91. The results of this study show that a valid and reliable scale was developed to determine the self-efficacy of middle school students' estimation skills. In addition, through the developed scale, it was obtained that self-efficacy of middle school students' estimation skills differed according to the type of gender and grade levels. It was observed that the self-efficacy of the male student regarding the prediction skill was higher than the female students, but this difference is not significant. In addition, When the self-efficacy levels of the students in estimation skills were examined according to their grade level, it is seen that the self-efficacy scores of the 5th and 6th grade students are higher than the self-efficacy scores of the 7th and 8th grade students.

*Keywords:*Estimation skills, Middle school students, Self-efficacy, Scale development.

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PART 2

PARALLEL SESSION 2 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

Transitioning the Elementary Mathematics Classroom to Virtual Learning

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In this study we explore the experiences of K-12 teachers as they transitioned from in-person to virtual learning due to the pandemic. The purpose of this study was to examine the best ways to support teachers in the challenges of providing effective equitable practices through virtual learning and how to continue to use those practices when returning to in-person learning. The National Council of Teachers of Mathematics (NCTM, 2014) provides a discussion of effective teaching practices. These practices are guiding principles that are used and referenced when studying instructional practices. The framework for this study focuses on several of these practices that pertain to learning mathematics conceptually, using high-quality mathematics tasks during instruction, facilitating productive mathematical discourse, and teaching with multiple representations of mathematical concepts.

The authors created an open-ended survey and conducted a qualitative content analysis. The survey asked teachers to identify their initial concerns, where and from who they received support in this transition, the tools and practices they found effective, and to reflect on how their virtual learning experience will impact their in-person instructional practices. Teachers' responses were read through several times, the researchers used memo-ing with notes in the margins as part of their analysis process (Mills, 2014). Color-coded highlighting was implemented to begin the open coding process (Miles et al., 2019). The codes were condensed into themes. For example, a theme for effective practices was mathematical representations and this was derived from coding and condensing responses such as "the use of hands-on manipulatives," "hands on learning strategies," "hands on manipulatives for kids, blocks, cubes, fraction pieces" and "lots of manipulatives, concrete-representation-abstract." The authors continued this process for the remaining questions.

The findings indicated teachers were concerned about providing multiple representations, specifically manipulatives, and working collaboratively with their students in a virtual environment as opposed to in-person learnings. The survey showed teachers were also concerned about discourse and providing authentic feedback. With these concerns in mind, they sought out virtual platforms that would facilitate an effective learning environment. The teachers responded to the survey question to identify effective tools. This was cross checked multiple times, and a list of virtual platforms was created with the frequency they were discussed. Virtual manipulatives and several interactive platforms such as Peardeck, Jamboard, Nearpod, and Flipgrid were identified as effective tools.

Teachers were asked to reflect on their experiences and discuss areas of growth and challenges. Responses indicated teachers grew through this experience in several ways. Teachers shared that they needed to "become a better math teacher" and "be very intentional." They examined the ways they were communicating and using technology to engage their students, responses included phrase such as "stretch", "not giving up", and "innovation." Most participants shared positive takeaways from the experience; however, other responses highlighted tensions and challenges. Some responses indicated teachers did not see value in virtual learning. They shared "*being virtual is so much less efficient than being in person*" and "*appreciation for the actual thing. None of this works as well as teaching in a* *classroom."* Technology use for mathematics learning varies from classroom to classroom. This transition was necessary, and many teachers were more ready to make this transition. The next questions were intended to understand how teachers were supported in this process.

The responses indicated teachers found support in a variety of places. One place of support noted by repeatedly in the responses was from one another. This was within their own schools and from teachers sharing their ideas and resources through social media. The data indicated that math coaches and technology specialists provided support, but these positions do not exist at all schools. There were also several responses that indicated teachers felt they received little to no support. When asked to identify desired support the teachers offered several suggestions. They wanted assistance with technology functions, professional development, greater collaboration with colleagues, support in making materials, and creating a virtual library for access to high quality virtual materials. This study provides insight into the resilience of teachers and their persistence.

Keywords: Professional Learning Communities, Mathematical Representations, Conceptual Fluency, Procedural Fluency,)

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We Asked Teachers: Do You Know What Dyscalculıa Is?

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Dyscalculia, which has a prevalence of approximately 3-8% in the population; is being defined as a special learning difficulty characterized by the inability to learn basic arithmetic facts, process numerical quantities, and make accurate and fluent calculations. Although dyscalculia is not the result of inappropriate pedagogical methods, appropriate knowledge, and educational practices those used for students are essential for a successful intervention. Teachers need to know about dyscalculia in terms of developing strategies and methods to meet the needs of students with dyscalculia. In this context, raising awareness about the general and specific symptoms of dyscalculia is also important in establishing an appropriate intervention program. When the studies on the knowledge and awareness of teachers about dyscalculia in Turkey are examined (Sezer, & Akın, 2011; Karadeniz, 2013; Karasakal, 2019; Kuruyer, Çakıroğlu, & Özsoy, 2019; Nurkan, & Yazıcı, 2020), it is seen that the number and variety of samples are limited. In the present study, besides the mathematics teachers working in middle and high schools; It has been worked with a wider group of participants, including primary school teachers, special education teachers, psychological counseling, and guidance teachers. *The main purpose of this study is to reveal the knowledge and awareness of teachers about the meaning, causes, characteristics, effects of dyscalculia, and intervention strategies for children with dyscalculia.*

Methods

A descriptive survey model was used in the research. The sample of the study consists of a total of 489 teachers, including 254 primary school teachers, 130 high school mathematics teachers, 53 psychological counseling and guidance teachers, 28 special education teachers, and 24 middle school mathematics teachers. In the study, a questionnaire developed by Dias, Pereira, and Van Borsel (2013) which including 2 open-ended and 16 closed-ended 18 questions was used. The questions aimed to get the views of the participants on five different knowledge areas including the concept of dyscalculia, the causes, characteristics, and effects of dyscalculia, and intervention strategies for dyscalculia.
Descriptive statistics such as frequency and percentage were used in the analysis of data obtained through closed-ended questionnaire items, while content analysis was performed using codes and categories for data obtained from open-ended questionnaire items.

Results

When the findings regarding the concept of dyscalculia and its meaning are summarized, it was seen that the majority of teachers did not have sufficient knowledge about dyscalculia, made incomplete and incorrect definitions, and some confused dyslexia with dyscalculia. From highest to lowest, inheritance (20.3%), attention deficit (17.9%), affective problems (14.4%), brain damage (11.9%), low intelligence (11.7%), social problems (11.5%), low quality of education (10.3%) and other conditions (2%) are ranked among the causes of dyscalculia by the participants. When the percentages of marked options are examined, it can be said that teachers do not have precise and sufficient information about the causes of dyscalculia.
Findings about the features of students with dyscalculia were determined that teachers did not have adequate knowledge to distinguish between non-dyscalculic students and students with dyscalculia. In general, it can be said that they are confused about the characteristics of children with dyscalculia, children with dyslexia and low achievement in mathematics. As a

matter of fact, the question "Can you understand if a student in your class has dyscalculia?" is responded as “yes” only by the 24% of the teachers.

In another dimension of the questionnaire, teachers' knowledge and awareness of the effects of dyscalculia were measured. It was determined that 53% of teachers did not consider a child's high math anxiety and a negative attitude towards maths and course materials as a dyscalculia effect. On the other hand, 88% of the teachers stated that dyscalculia can cause restlessness, anxiety and behavioral changes. When both questions are evaluated together, it is understood that the answers given by the teachers are not consistent and they do not have sufficient knowledge about the effects of dyscalculia.

Examining the responses to the intervention strategies for dyscalculia, it was seen that the intervention strategies can be evaluated under 3 themes such as guidance, educational intervention and information gathering. 48 participants stated that they lead the students they suspected of having dyscalculia to the Counseling and Research Center in the city or to the guidance service of the school. 9 participants stated that they made an educational intervention to these students. In addition to these, when they exposed the question who should make educational intervention to children with dyscalculia, the 34.5% of the participants stated that the people who should intervene in a student with dyscalculia should be teachers. Approximately 31% of the participants stated that they should be pedagogues and 23.6% of the participants stated that they should be a psychologist who should make educational intervention to children with dyscalculia.

Conclusion

The findings obtained in this study demonstrate similarities with the results of many national and international studies (Sezer, & Akın, 2011; Karadeniz, 2013; Karasakal, 2019; Kuruyer, Çakıroğlu, & Özsoy, 2019; Nurkan, & Yazıcı, 2020; Shalev & Gross-Tsur 2001; Chinn & Ashcroft 2006; Butterworth, Varma & Laurillard, 2011; Tennant & Tennant, 2010). As a result, it can be said that the teachers are generally not familiar with concept of dyscalculia and do not have sufficient knowledge about how to intervene with dyscalculia.

Keywords: Dyscalculia, Dyscalculia awareness, Teacher’s opinions

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Students' Cognitive Demands in Algebra: Basis for the Development of a Learning Module

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This sequential explanatory research is aimed at looking into students' Algebraic Conceptions in terms of the six cognitive demands categorized as Visualization, Knowing, Computing, Solving, Applying, and Proving as a basis for the development of a stand-alone learning module. The theoretical framework of this study is based on Piaget's Developmental Theory of Knowledge (Piaget, 1970), which implies that learner's mental structures are evolving to accommodate new learning and knowledge brought about by maturity and environment. The researcher sought to answer the following questions: 1) What are the least mastered competencies in Patterns and Algebra?, 2) What are the students' conceptions in Patterns and Algebra in terms of cognitive demands namely Visualization, Knowing, Computing, Solving, Applying, and Proving?, 3)How are these conceptions manifested in students' answers on the test?, 4)What instructional material can be developed based on the least mastered competencies?, and 5) What are the students' experiences in using the module/instructional material? The respondents were eighty-five (85) Grade 7 High School students who took a researcher-made Algebra test, out of whom eight (8) were subjected to an in-depth interview. The ADDIE model was used for the development of the module. The statistical tools used for quantitative data analysis were frequency, percentage, mean, and standard deviation while the quantitative data were analyzed using the steps by Creswell (2014). The results showed that students were "poor" in Solving, "fair" in Visualization, Knowing, and Applying, and "good" in Computing and Proving. It further revealed that student's Knowing and Visualization skills were hampered by not able to remember entirely the topic, their Computing and Solving skills were restricted by their lack of problem-solving tools, and their Applying skills was not developed due to time-constraints. Additionally, the top three least-mastered competencies were (1) solves linear equation or inequality in one variable involving absolute value by: (a) graphing; and (b) algebraic methods, (2) solves problems involving equations and inequalities in one variable, and (3) illustrates linear equation, and inequality in one variable which became the content-focus of the module. There was a positive increase in the students' post-test results when the module was used by the students. Finally, students have had varied descriptions of their experiences in using the module. In sum, the researcher concluded that students (i) have inadequacy in the six cognitive demands in Algebra, (ii) have lack of sufficient exposure to different mathematical endeavors especially in problem solving, and (iii) have limited ability to verbalize mathematical knowledge into the English language. Thereby, it was recommended that all stakeholders may consider the use of a stand-alone learning module as a learning tool in Mathematics.

Keywords: Cognitive Demands, Algebra, Learning Module

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PART 2

PARALLEL SESSION 3 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

On Methods of Finding a Set of Values of a Function

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The work provides some recommendations for solving problems of finding the set of values of the function. The problems of finding the set of values of a function are mainly solved by the following methods:
-method of evaluations;
-using of the properties of continuity and monotonicity of functions;
-using of a derivative;
-graphic method;
-the method for finding the domain of definition of the inverse function;
-using of the largest and smallest values of the function, etc.

The paper provides various examples of finding a set of values for different functions.

Keywords: domain of definition set of meanings, estimation method, graphical Method, continuity, evenness, oddness.

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New Approaches to Solving School Geometry Problems

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In this work, we consider some applications of Ptolemy's theorem. Namely, using Ptolemy's theorem,

1) We prove some property of a point lying on a circle circumscribed about some regular triangle;
2) We prove some property of a regular heptagon;
3) We find a criterion for constructing an inscribed hexagon.

Keywords: Ptolemy's theorem, inscribed rectangle, regular heptagon, inscribed hexagon.

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The Role of ICT in the Solutions of Stereometric Type Questions in Higher Classes

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In this article, self-control of knowledge, increasing of more interactive geometry studying, usage of dynamice geometry, solution of stereometric problems, distance, evaluation of angles and such a theoritical and educational processes of mathematics are considered. Moreover, analysing of student's problem solving methods, as a tool self-control management and management of calculation problems of Live Geometry from live geometry by applying stereometric are given.

Keywords: Education, living geometry, figur cube, angle, equilateral triangle,

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PANEL 1: ONLINE LEARNING AND TEACHING MATHEMATICS (USA EST 1:20-2:20 PM / TR 20:20-21:20)

Moderator

Dr. Brooke Max, Purdue University, USA

Prof. Dr. Signe Kastberg

As a scholar of teaching and learning, Dr. Kastberg explores and contributes to public understanding of mathematics teaching and learning and mathematics teacher education. Dr. Kastberg's discovery, learning, and engagement activities are undertaken to develop and contribute to understandings of the beauty and complexity of teaching, learning, and learning to teach mathematics-learners.

Associate Prof. Gina Borgioli Yoder

I am interested in issues of equity and educational change in mathematics and language education as they relate to pedagogy, policy, and teacher education. My knowledge and experiences as a middle school ENL teacher, INDOE Language Consultant, ENL teacher educator, and researcher drive my interest in issues of equity for multilingual learners and their teachers. My knowledge andexperiences as a middle and high school mathematics teacher, building administrator, teacher educator, and researcher drive my interest in issues of equity in mathematics teaching and learning.

Associate Prof. Enrique Galindo

Dr. Enrique Galindo is an Associate Professor of Mathematics Education at Indiana University Bloomington. He is interested in research on teacher education and on learning in technology-supported environments. He teaches courses on mathematics and pedagogy, secondary mathematics methods courses, and graduate courses for teacher educators. He has directed many large-scale funded projects and has many years of experience with professional development. He has conducted professional development projects to help teachers in grades K-12 improve teaching and learning in STEM education, incorporate Project Based Learning, and develop their technological and pedagogical knowledge to improve their teaching.

Associate Prof. Betsy Berry

Research Interests: Portfolio assessment in mathematics content courses, attitude and affect in mathematics teaching and learning, technology in mathematics education, learning through inquiry and group problem solving.

DAY 2 – MAY 27, 2021

KEYNOTE SPEAKER – ASSOC. PROF. ENRIQUE GALINDO

“Consideration on the Preparation and Professional Development of Mathematics Teachers”

Assoc. Prof. Enrique Galindo

Indiana University, USA

(17:00, Turkey) (10:00AM, Eastern)

PART 3

PARALLEL SESSION 1 (USA EST 11:00 AM – 12:00 PM / TR 18:00 – 19:00)

Analysis of Future Primary School Teachers Knowledge About the Decimal Numbering System

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The objective of the study is to know the different forms used by students of the Primary Education Degree (PED), at the end of the subject Mathematics and its Didactics 1, to solve a problem in which concepts of the Decimal Numbering System (DNS) intervenes.
The research questions are: How do these future teachers solve an DNS problem? What techniques do they use? What errors or difficulties do they present?
Castro, Gorgorió and Prat define Fundamental Mathematical Knowledge (FMK) as the basic disciplinary knowledge in mathematics necessary for the PED student to successfully build the pedagogical knowledge of the content. It includes the knowledge of concepts, procedures and processes for solving problems that they learned during their schooling stage and that they need when they start their training. These authors affirm that, within the FMK, arithmetic is a basic component.
Likewise, Montes, Contreras, Liñan, Muñoz-Catalán, Climent and Carrillo (2015) indicate that “an element that we understand must form a fundamental part of the knowledge of the subjects of the students of PED is the decimal numbering system (DNS), in which it is deepened through questions about its properties and foundations” (p. 46).
Problem-solving processes (…) constitute the cornerstone of Mathematics education (RD 126/2014, p. 19386) and it also specifies that “to achieve true numerical literacy (…) it is necessary to act confidently when faced with numbers and quantities, use them whenever necessary and identify the basic relationships that exist between them”. Within the

requirements for the verification of university degrees that enable the exercise of the profession of Primary Education teacher, it is specified, among others, that they must acquire basic mathematical competencies, know the school mathematics curriculum and propose and solve problems related to daily life.
The students who access the PED remember the DNS, for the most part, in a vague and memoristic way without having made the necessary reflection of its meaning, of the grouping of ten by ten, in turn extensible to other groups and where the consideration of writing a number in both positional and polynomial form or decomposing a number is far from its interpretation.
19 students taking the subject Mathematics and its Didactics 1 (2nd PED course) of the Faculty of Education of the University of Murcia participate. In this subject mathematical and didactic contents related to the DNS are worked on.
In a final exam, the following problem is proposed:
A number made up of three different digits verifies that: 3 · abc = bbb. What is the value of a + b + c?
The answers given are analyzed and three types of reasoning are observed, all based on the trial-error technique:
• Dividing by 3 (3 students). They write the equation algebraically, give all possible values to bbb, divide by 3 and check that abc fulfills the equation.
• Multiplying by 3 (3 students). They give values to a, b and c by finding the digits that, multiplied by 3, give another number where the three digits are equal to the tens of the requested number. They do the multiplication by reviewing the table of three and checking which digits are valid with the conditions of the problem.
• Polynomial decomposition (4 students). 3 abc = bbb 3 (100a + 10b + c)

The main errors detected are:
• Incorrect solving for bbb in the expression abc = bbb / 3 (1 student).
• Ignorance of the DNS. Consider bbb = b3 (2 students).
• Errors multiplying or dividing (3 students).
• Errors when simplifying algebraic expressions (1 student).
• Illogical answers or choice of inappropriate strategies (4 students).

Only four students who apply an adequate strategy manage to solve the problem, two dividing and testing all the possibilities until they find the result of 148 and two based on the multiplication table of 3. However, having worked the polynomial form of a number within the contents of the subject none can reach the solution in this way.
More than half of the students have zero or leave it blank, implying that they have not acquired mathematical competence in numbers and specifically in the DNS.

Keywords: Didactics of Mathematics, Decimal Numbering System, Degree in Primary Education**.**

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Figured Mathematics Worlds, Figured Rural Worlds: Narratives of Becoming College-Bound in a Rural Mathematics Classroom

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The modest body of mathematics education research done in the context of rural schools tends to prioritize quantitative measures of achievement (Cuervo, 2016; Howley, 2003; Howley, Howley, & Huber, 2005). The purpose of this study is to understand how students in a rural public school experience and construct relationships with mathematics, contributing qualitative findings to this body of research. I ask the grand research question: How do students in a rural college-preparatory mathematics course develop identities as being college-bound? To answer this question, I ask three sub-questions:

1. How do their experiences and relationships with school mathematics influence this process?
2. How do their experiences and relationships with mathematics as a part of their everyday lives as people living in a rural community influence this process?
3. How do students negotiate the convergences and divergences between these two sets of experiences and relationships?

Boaler and Greeno (2000) argue that: "The mathematics classroom may be thought of as a particular social setting—that is, a figured world—in which teachers and children take on certain roles that define who they are" (p. 173). I assert that rurality can be conceptualized as a figured world, enabling one to do mathematics education research that is distinctly rural. Holland, et al. (1998) argue that narratives are a cultural means around which figured worlds are formed. Based on this insight, I am conducing this study as a narrative inquiry.

As I spent five months observing an AP Calculus course at a rural high school in the Midwestern United States, I conducted two group interviews and two individual interviews with the five participants, two interviews with their teacher, and an interview with the school's college counselor in addition to keeping field notes on the mathematical and social activity in the classroom. From these field notes and transcribed interviews, I am writing narratives of participants' paths toward college, focusing on the role of mathematics and their rural educational context. The primary data analysis technique is emplotment, which refers to the determining and sequencing significant events, places, and people in ways that make meaning out of the larger phenomenon of interest (Polkinghorne, 1988). Clandinin and Connelly (2000) conceptualize this process as working within a three-dimensional narrative space that consists of temporality, social interaction, and location.

Preliminary narrative analysis has been completed for two participants: Stacy and Bridgette (both pseudonyms). Both told of how success in mathematics, operationalized through high grades, is a critical component of their path toward college. However, Stacy's experiences growing up in an academically-oriented family brought her to value conceptual understanding in addition to grades. Bridgette, who grew up on a farm, placed less importance on conceptual understanding of mathematics and more importance on the ways in which mathematics can be applied to her desired future work as an agronomy researcher. Both participants saw success in college, which they saw as largely depending on success in mathematics, as necessary to avoid a life of poorly-compensated labor that is increasingly common in their home town.

Keywords: Mathematics identity, rural, narrative

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Using Old Pedagogical Journals as a Tool with Prospective Infant Teacher Training

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The use of original sources is a useful tool not only to be used with secondary school students (Jahnke et al., 2000) but also with prospective mathematics teachers (Alpaslan, Işıksal & Haser, 2014). Arnal-Bailera and Oller-Marcén (2020, p. 254) point out that "working with original sources that involve pedagogical content […] might be an interesting line of research in the context of mathematics teacher training".
Pedagogical journals played a very important role in the development of professional teacher associations (Krüger, 2017), which was a world-wide phenomenon (Schubring, 2015). However, its use as a tool in a teacher-training context does not seem to have been expored.
In this work in-progress, we seek to explore the impact of using old professional pedagogical journals in order to foster pedagogical content knowledge in pre-service infant teacher training. In order to do so, we designed a series of activities that were carried out with 119 students from the Degree on Infant Education. Among other tasks, the participants were required to perform a critical analysis of a 1949 excerpt from the journal Escuela Española [Spanish School].
The selected excerpt was originally addressed to in-service Spanish elementary education teachers and it described a sort of teaching sequence for 5-7 year old pupils dealing with very elementary aspects of arithmetic. It included the reading and writing of numbers from 1 to 9, their interpretation both as cardinals and ordinals, and basic ideas related to addition and subtraction (including easy verbal problems).
To analyze the participants' written productions, we adopt a qualitative and interpretive approach. Our main analytical tool is the MTSK model developed by Carrillo-Yáñez et al. (2018). This model of teachers' knowledge was developed as a reconfiguration, reinterpretation and reconfiguration of MKT (Ball, Thames & Phelps, 2008).
This model turned out to be a powerful and appropriate instrument. A preliminary analysis of some of the students' productions shows that there may be different profiles among the prospective teachers related to the different sub-domains of the MTSK model that they bring to play when reading the excerpt.
Further work is thus required in order to identify and describe these profiles and to provide useful implications for teacher training.

Keywords: Teacher training, Infant education, Original sources, Pedagogical journals.

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PART 3

PARALLEL SESSION 2 (USA EST 11:00 AM – 12:00 PM / TR 18:00 – 19:00)

Teachers' Understanding of Geometric Reflections: Motion and Mapping Perspective

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The topic of geometric transformations has an important place in mathematics education not only for understanding other mathematical and geometry topics (function, congruence, similarity, and symmetry) but also for understanding and interpreting phenomena in everyday life (Flanagan, 2001; Hollebrands, 2003; Yanik, 2006; 2014).The aims of this study were to investigate high school mathematics teachers' perspectives on geometric reflection and to determine the mathematical factors that affect their transition from a motion to a mapping perspective. This study was carried out with four high school mathematics teachers working in different private schools in Ankara during the 2020-2021 academic year. A multi-case study design was used in the study (Yıldırım & Şimşek, 2011). Interviews were used as a data collection tool. Data analysis was guided by APOS (action, process, object, and schema) theory, a framework for the mental construction of mathematical concepts (Asiala et al., 1996; Dubinsky, 1991). The findings revealed that all four mathematics teachers had a motion perspective according to the symmetry axis sub-concept in understanding geometric reflection, as they correctly applied the equidistance and perpendicularity features, which is the role of the symmetry axis. On the other hand, it was found that three teachers had a motion perspective according to the domain sub-concept, and only one teacher provided evidence of transitioning to the mapping perspective. It was also determined that all four teachers had a motion perspective according to the plane sub-concept because they stated that they applied the geometric reflection only to the shape, perceiving that it moved across the reflection line, and not to the whole plane when they performed a geometric reflection, indicating that they could not yet switch to the mapping perspective. This study of teachers' perspectives on geometric reflection makes a valuable contribution to the literature as there are few studies addressing this issue, which is critical to the effective teaching of geometric reflection.

Keywords: In- service teachers, geometric reflections, motion perspective, mapping perspective

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Reasoning Skills, Content Knowledge, and Conjecturing Ability of Pre-service Mathematics Teachers

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This mixed-method study would like to ascertain, the level and relationship of conjecturing ability of pre-service mathematics teachers to their reasoning skills and content knowledge. Specifically, it seeks to answer the following: 1) What is the level of content knowledge, reasoning skills and conjecturing ability of pre-service mathematics teachers? 2) Is there a significant relationship between reasoning skills, content knowledge and conjecturing ability? 3) Is reasoning skills and content knowledge significant predictor of conjecturing ability? 4) What are the problems, difficulties and hindrances emerged and experienced by pre-service mathematics teachers in producing conjectures? 5) How did the pre-service mathematics teachers cope with those difficulties to generate conjectures?
The following illustration in Figure 1 shows the interplay of the variables in the study.

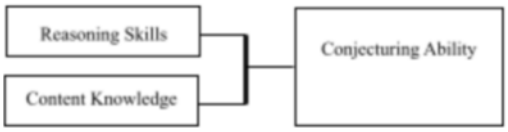

Figure 1. Conceptual framework showing conjecturing ability, reasoning skills and content knowledge.

The participants of the study were 25 pre-service mathematics teachers. The data-gathering instruments were three multiple-choice tests for reasoning skills, content knowledge, and conjecturing ability. In-depth interview was conducted to determine the problems and difficulties in generating conjectures, and how to cope with these problems and difficulties encountered. The mean was used to determine the pre-service mathematics teachers' level of reasoning skills, content knowledge, and conjecturing ability, and the standard deviation in determining the scores' homogeneity or heterogeneity. Pearson's Product Moment Correlation Coefficient (Pearson's r) was utilized to determine the relationship among the variables while step-wise linear regression analysis was used to determine the predictor of conjecturing ability and the model of regression. Statistical computations and processing were done through the Statistical Package for the Social Sciences (SPSS) software version 23. The 0.05 level of significance for two-tailed test was used for inferential test. After collecting quantitative data and analyzing its result, qualitative data analysis was utilized to support in detail the initial quantitative results. This was done through thematic analysis. Results revealed that pre-service mathematics teachers have "average" level of content knowledge (M = 24.52, SD = 4.45) and conjecturing ability (M = 55.60, SD = 6.23) while "high" reasoning skills (M = 24.24, SD = 3.63). It was found out that content knowledge and reasoning skills has significant relationship (r = .495, p = 0.012) same with content knowledge and conjecturing ability (r = .376, p = 0.007). On the contrary, reasoning skills and conjecturing ability has no significant relationship (r = .525, p = 0.064). The result of linear regression analysis indicates that content knowledge was the only predictor of conjecturing ability (p = 0.007). The resulting regression equation would be $y = 37.545 + 0.736 (x)$, where y is the dependent variable or the conjecturing ability and x is the independent variable or the content knowledge. The resulting regression equation means that for each one unit increase in content knowledge is associated with 0.736 unit increase in conjecturing ability. Pre-service mathematics teachers encountered problems and difficulties in making conjectures. Two problems reflected were their retention of previous lessons because they tend to forgot lessons through time, and on how they perceive the subject geometry wherein, those who hate geometry got low, while those who love it got high. In facing those problems and difficulties, students used the following in order to cope with it. It is through their: a) remembering past lessons b) looking for pattern, and c) identifying the given using of figures, visuals and illustrations. Since pre-service mathematics teachers' content knowledge and conjecturing ability were Average, pre-service teachers have some misconceptions to understand concepts in Geometry. Content knowledge and conjecturing ability go together. The degree of content knowledge is positively related to the degree of how they make conjectures, or even vice versa. Improving pupil's content knowledge can help them enhance their conjecturing abilities. As content knowledge being a predictor of conjecturing ability, mastery of content, reviewing it and continuously learning it would really help in developing mathematical vocabulary and stored knowledge needed to generate conjectures.

Keywords: Conjecturing Ability, Reasoning Skills, Content Knowledge, Pre-service Teachers

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Teachers' Views on Online Mathematics Teaching Barriers during the Covid-19 Pandemic: The Case of Turkey

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Purpose of the study

Since the World Health Organization (WHO) declared COVID-19 a global emergency on January 30, 2020 and a global epidemic on March 11, 2020, the schools, students and teachers in 213 countries have been affected by the pandemic. Online teaching and learning, which provides flexibility for the education environment, is an important education model that complements face-to-face education. During the COVID-19 outbreak in Turkey, closure of schools affected 26.1 million students and 1.3 million teachers, and the education system has become dependent on online teaching and learning. In our country, online teaching and learning is a relatively new experience for most teachers and students, and it does have an impact on the quality of education. The aim of this study is to examine teachers' views on online mathematics teaching barriers during the COVID-19 pandemic. It examines four kinds of barriers: teacher, technology, course content, and student.

Research question(s)

- What are the teachers' views on online math teaching barriers?
- Do teachers' views on barriers to online mathematics teaching differ significantly according to their gender and school types?

Theoretical framework or perspectives

Most of the studies about the barriers to implementing online teaching have been done in normal situations where the use of e-learning is optional to improve the teaching and learning process (Hadijah & Shalawati, 2017; Juliane, Arman, Sastramihardja, & Supriana, 2017). There are only few studies that investigate the use of e-learning during pandemics (Ash & Davis, 2009) and most of the studies do not focus on mathematics (Astri, 2017). In addition, most studies on e-learning barriers are done in the context of students' experiences (Rabiee, Nazarian, & Gharibshaeyan, 2013). Therefore, it is important to investigate the barriers to online mathematics teaching experiences during the pandemic by investigating the experiences of middle school mathematics teachers and elementary teachers.

Methodology

A quantitative approach was used in the study. The "E-Learning Implementation Barriers" scale developed by Mailizar, Almanthari, Maulina and Bruce (2020) and adapted to Turkish within the scope of this study was used. An online questionnaire was used to collect data from 364 middle and elementary math teachers. A crucial reason for using an online questionnaire was compatibility with teachers' online work during the pandemic. Reliability and validity examinations were carried out for the Turkish adaptation of the scale used in the study. Descriptive and inferential statistical analysis will be used to answer the research questions. Regarding descriptive analysis, mean and standard deviations of the responses for all items of the scale will be calculated and presented in tables. For inferential statistical analysis, parametric or non-parametric tests will be used according to the normality of the data.

Preliminary results

The findings of the study show that the student-level barrier has the highest effect on online learning use. The findings of this study reveal the controversial results in overcoming the obstacles to teachers' mathematics lesson online teaching practices. A Pearson correlation coefficient was computed to assess correlation between categories of the barriers. There were strong and moderate positive correlations across the levels. The first strongest correlation was between the school level barriers and curriculum level barrier. The second strongest correlation was between the school level and student level barriers. The third strongest correlation was between the student level and curriculum level barriers.

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PART 3

PARALLEL SESSION 3 (USA EST 11:00 AM – 12:00 PM / TR 18:00 – 19:00)

Teaching Learning Child to Parent

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In order for children to be more successful and develop positive attitudes towards mathematics, appropriate educational environments and materials should be provided (Arnas, 2004). At this point, home activities can also come to mind. Home activities; it can be said that it is an out-of-school activity that guides students to support their parents, provides students with a fun environment, requires students to be active in their classes so that they can do their activities in the best way, teaches them to take responsibility, and contributes positively to the level of success (Tayan, 2019). Parents helping their children with homework, playing games or spending time with them can provide students with an interactive study model. İn our learning method which is teaching learning based upon to see efficiency of doing homework from children to parents. Aim of this study is doing homework how effects success, interest of putting into practise this method we want to define acception of children and parents. The study carried out with classes 7th midle school students and their parents. One of the group was chosen as the treatment group in which this method was used, while the other class was chosen as the comparison group.This study was carried out using a triangulation design, a type of mixed research design. Data were obtained from a knowledge test, from a semi-structured interview, and from focus-group discussions. As a result of the data analysis, it was found that this method positively contributed to the success. In addition, students have been taught to make homework more enjoyable in learning environments by teaching and to increase the motivation and knowledge within the lessons. Students also stated that it became easier to give meaning to topics and concepts, and that their learning was more permanent in this environment. According to the quantitative data results obtained from the research, the method of learning by teaching from child to parent is a useful method in academic success.

Keywords: Teaching Learning Child to Parent, Academic Success, Communication.

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Pre-service Teachers' Use of Proportional Reasoning Skills to Solve the Area Measurement Problems of the Rectangles

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The literature indicates that students generally have difficulties in understanding the measurement concepts. In addition, students have difficulties associating the measurement concepts and including them in the problem-solving process. Especially, in area measurement, many studies have revealed that students and teacher candidates have misconceptions and their level of understanding of area measurement is low (Chappell & Thompson, 1999; Bilir, 2018; Huang v& Witz, 2013; Kamii & Kysh, 2006; Karaca, 2014; Maher & Beattys, 1986; Olkun, Çelebi, Fidan, Engin & Gökgün, 2014; Şişman & Aksu, 2011; Woodward & Byrd, 1983; Zacharos, 2006). In addition, it was stated that students memorized the formulas for area and circumference measurement, so they have problems understanding the concepts and formulas of area and circumference measurement, and had difficulty in applying the formula to the given situation (Chappell & Thompson, 1999; Grant & Kline, 2003; Martin & Strutchens, 2000; Stephan & Clements, 2003). In addition to these, it was found that the students had problems in area conservation (Tan Şişman & Aksu, 2009; Woodward & Byrd, 1983). Since measuring the area of objects involves the multiplicative relationship, learning this subject is related to the proportional reasoning level (Taylor & Jones, 2009).

Proportional reasoning is one of the types of mathematical reasoning, which requires deeper knowledge to solve problems and is a way of reasoning about multiplicative situations (Van de Walle, Karp, & Williams, 2014). The literature on proportional reasoning indicates that students could not establish the relationship between additive reasoning and multiplicative reasoning or could not distinguish the two situations (Van Dooren, De Bock, Gillard, & Verchaffel, 2009; De Bock, 2008; Lim, 2009; Çelik & Özdemir, 2011).

The critical role of proportional reasoning requires us to investigate the relationship between area measurement and proportional reasoning in depth. For this purpose, our research questions:

1. What is the level of pre-service teachers' understanding of the area measurement of the rectangle?
2. How did the pre-service teachers use proportional reasoning in rectangular area measurement problems?
3. What is the relationship between pre-service teachers' understanding of the area measurement of the rectangle and their proportional reasoning skills?

Case studies from qualitative research methods will be used in this study. The data of the study will be collected face to face at a university in Central Anatolia in the fall semester of the 2021-2022 academic year. Participants will be selected from among pre-service mathematics teachers by random sampling which is one of the probability sampling methods (Yıldırım, Şimşek, 2018). In the study, the participants' worksheets, the camera recordings, and the researcher observation form will be used as data collection tools. In analyzing the data, the Levels of sophistication framework of Battista (2004) and a robust understanding of the proportional reasoning framework of Weiland, Orril, Nagar, Brown, and Burke (2020) will be used. The pilot study of our study, in which two pre-service teachers participated, has been completed and data analysis is currently in progress.

Keywords: Area measurement, proportional reasoning, pre-service teachers

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Mathematics as My Fairy Tale

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It must be due to the nature of mathematics that includes more abstract than concrete concepts; it has been an area where students often had difficulties in achieving, striving and being motivated. It can be thought that the use of different activities for students with different intelligence types to develop the sense of love and achievement in mathematics will meet the expectations of the teaching. At this point, it can be said that there is a need for methods that will facilitate students' learning by concretizing abstract concepts. “Tales”, which have been passed down to us as an oral heritage from our ancestors from the past to the present, appears as a way of teaching in this sense. According to Boratav (1969), fairy tales are tools that prepare people for life, especially starting from childhood, and aim to raise a self-confident individual in the cultural environment in which they live. For this reason, the educational functions of tales have been considered important and it has been emphasized in many places that especially feeding children with fairy tales will be beneficial for their development (Yılmaz, 2012). Based on the point of overcoming the fear of mathematics and the feeling of failure, which is one of the aims of today's mathematics education, it has been used in teaching tales that cause them to learn secretly in an adventure that will motivate them. In this study, views on fairy tale telling, which is used to make the mathematics including abstract concepts more concrete and to teach the target behavior to the student in a latent way, were put forward. The study was conducted during the 2020-2021 second semester of the academic year with 5th grade (N = 15), who portrayed mathematical subjects and concepts in their own fairy tale world. First of all, while teaching the concepts in the curriculum by the teacher, students' attention was drawn with a small storytelling and rhymes were used to make the abstract concept understandable in the student's mind. After the teacher gave the students target behaviors related to the subjects, she asked them to design fairy tales. Students taught various mathematical topics with rhymes and animations they designed in their minds. At the end of the unit, each student told their own fairy tale to their classmates in the classroom and conveyed the general repetitive information to their friends without notice. The case study was conducted in the research and the opinions of the students about the study were taken throughout the process. The obtained data were described by examining in depth. Students who designed fairy tales according to semi-structured interviews stated that they were happy and their motivation increased because of the responsibility they took. They stated that they had fun by listening to fairy tales from their grandparents before, and now being able to create and use them in a lesson made them feel different feelings. They also said that their imaginary worlds developed and that they created a space where they could express mathematics in concrete form. In the process of fairy tale design, they stated that they understood that the concept must have been learned correctly. They stated that they felt obliged to motivate themselves to learn during the lesson in order for the process to run positively. The opinions of the students who listened to the tale showed that they learned the mathematical concept of the subject without realizing it and that they thought of mathematics as a cute lesson. It can be said that the students who both told the tale and listened to the story along with the study provided latent learning. In addition, it can be said that the method of learning mathematics through fairy tales will play an active role in keeping our cultural heritage alive from generation to generation. Fairy tales can be thought of as a fun and useful way for students who are biased towards math class. In general, it has been found that fairy tale telling method in mathematics education is an effective method at secondary school level.

Keywords: Fairy Tale, Mathematics, Cultural Heritage, Latent Learning, Concretization

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PARALLEL SESSION 1 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

What Drives Teachers' Decisions? : An Exploration Knowledge and Beliefs

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In this study, I explore a teacher's journey in using a relatively new curriculum. The teacher was part of a collaborative group that designed a unit about fractions for fourth grade students and then implemented it in their classrooms. The unit design process was guided by a constructivist learning and teaching approach. It was a relatively new approach for the teachers as most of them had been using textbooks that embraced a traditional teacher-centered approach to learning mathematics. After I examined their unit implementations, I found that the teachers in the group had different levels of fidelity in their implementation of the designed unit. When I investigated the reasons behind their decisions in implementing the unit, I found one particular case to be different from others as the teacher had low fidelity levels but believed his implementation to be on point. I decided to examine his case more closely to find out the underlying reason behind this disparity. The questions I investigate here are "What are the factors behind the teacher's implementation decisions (whose implementation practices mostly misalign with the designed unit)?" and "What role do these factors play in teacher's unit implementation decisions?"

Conceptual Framework

Embracing and acting on constructivist approach to learning and teaching is more complex than it sounds (Manouchehri & Goodman,1998). First of all, it requires teachers to change their beliefs about teaching and learning accordingly if they had not already carried those beliefs. We know that beliefs are one of the most influential factors on teachers' instructional practices (Beswick, 2005; Ernest, 1989; Philipp, 2007). A teacher who has a constructivist approach to learning and teaching would believe that their job is to guide students through their learning experiences – not to tell them everything without giving them a chance to explore mathematical ideas, and would try to employ appropriate teaching practices to create a student-centered learning environment. At this point, another necessary component of quality teaching comes into play, that is mathematical knowledge for teaching (MKT) (Ball, Thames & Phelps, 2008). In order to decide what kind of teaching practices would be good for a student-centered instruction, teachers need to have the knowledge of the content, the curriculum and the pedagogical content (Shulman, 1986; Ball, Thames & Phelps, 2008). A teacher with a strong MKT would be more likely to employ quality teaching practices that are in accordance with constructivism in their classrooms.

Methods

This is a single case study where only one teacher's experiences and ideas are being examined. The teacher was male and had 3 years of teaching experience in elementary grades. He was teaching 4^{th} grade when this study took place. He used the textbook series Everyday Math in his math classrooms. The most advanced mathematics course he had taken was Elementary Math Concepts. Based on my prior observations, his instruction was mostly error free direct instruction with some student input.
I conducted a semi-structured interview with the teacher prior to and after the unit implementation. The questions in the interview asked the teacher to talk about their beliefs

about mathematics and teaching and learning mathematics in addition to his self-efficacy beliefs. I also used an MKT survey about fractions to determine the teacher's level of mathematical knowledge for teaching fractions.

Results

The results from MKT survey showed that the teacher's understanding of fractions had some gaps indicating a low to moderate level of conceptual knowledge on fractions. He was able to understand student mathematical thinking, but he was unable to unpack it and communicate clearly what was missing in students' understanding and to provide a complete and appropriate activity to address students' needs – indicators of a low to moderate level pedagogical content knowledge.

The teacher agreed to statements such as "Students can learn to apply mathematics only after they have mastered the basic skills" and "An effective teacher makes the mathematics easy for students by guiding them step by step through problem solving to ensure that they are not frustrated or confused" during the interview – indicating that he mostly had a teacher-centered approach to learning and teaching mathematics.

The teacher's self-efficacy beliefs about his mathematical knowledge and teaching were also considerably high. He also believed that he was more confident than before and that was particularly due to realizing different kinds of sources he could use and collaborating with other teachers to figure out new ways to improve their teaching. He also added, "Confidence is based on how frequently and often you do something effectively, applies to math knowledge" when talking about his efficacy regarding his mathematical knowledge.

All results taken together, it might be concluded that the teacher's high self-efficacy levels might have impacted his decisions in what to teach and how to teach it during the unit implementation even though it appeared to have a negative impact on the alignment of his unit implementation. That might be because his decisions were made under the influence of his mathematical beliefs and since these beliefs were mostly in contradiction with what was intended in the designed unit, his fidelity of implementation was considerably low. Also, he believed he had a considerably high level of mathematical knowledge, which actually was not true according to MKT survey results. Based on that, we might say his low level of MKT might have misguided him in his decisions about how to teach a particular concept yet his confidence in his knowledge and teaching might have hindered him to realize what he was actually supposed to do according to the designed unit. Further discussion and conclusion will be shared during actual presentation.

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An Investigation of Reasoning and Modeling Skılls of Pre-School Students in Pattern Activities

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Pattern is the basis for understanding the order and logic of mathematics as well as questioning mathematical relationships (Baroody & Coslick, 2000). Matching, classification, comparison, and sequencing skills are included as basic mathematical skills in the preschool period (Waters, 2004). With the ordering, which is one of these skills aimed to be developed, according to certain rules, pattern activities appear in the preschool period. In this study, it was aimed to examine the reasoning and modeling skills used by students in pattern activities carried out with pre-school students. Participants were 10 students attending pre-school. Students are around 5-6 years old. The study was designed as a case study to examine students' skills in detail. The checklist prepared by the researchers and the video recordings of the activity processes were used as data collection tools in the study.
7 pattern activities developed by the researchers were used in the study. These activities consist of nonnumerical and recursive (AB-AAB-ABC-ABCD) pattern types. These activities were designed and selected carefully to ensure that they are appropriate for the cognitive characteristics of young children, and accordingly, real object patterns and pattern cards were used. At the same time, the content of the activity was enriched with linear and cyclic repetitive pattern examples. Pattern activities were carried out from simple pattern (AB) to complex pattern (AAB-ABC-ABCD), and thus students were supported to form advanced patterns. Color-shape pattern card (AB), day and night pattern (AB), animal figures pattern (AB), wearing bracelets pattern (AB-AAB-ABC), geometric shape pattern (ABC) and season pattern (ABCD) activities were carried out with the students in this study. Pattern activities were implemented in accordance with the steps of recognizing, continuing, and creating the pattern.
It was seen that in the pattern steps performed, students make generalized by explaining, establishing cause-effect relationship, persuasion, and defining the pattern rule. It was concluded that the pattern activities performed with the emergence of these skills were effective on the development of students' reasoning skills. It was seen that the students formed their own patterns by determining their own rules, as well as studying the relationship to the pattern sample presented, thus the activities were also effective in the development of modeling skills. In line with the results obtained from this study, it was concluded that the pattern activities at the pre-school level were effective in revealing and supporting the development of students' reasoning and modeling skills.

Keywords: Pattern activities, reasoning skills, modeling skills, pre-school students

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Project Vlogi (Video on Giving Instruction): Its Effect on Students' Performance in Probability

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This experimental study ascertained the benefits of project VLOGI (Video Lectures on Giving Instruction) to Grade 8 learners and mathematics teachers to resolve the mathematical content issues in probability. The researcher observed that this content has a low level of proficiency in higher grade levels of all time since it falls in the last quarter of the school year. Thus, some mathematics teachers teaching in the lower grades tend to skip or fail to teach the learning competencies due to lack of time, resulting in spiral deterioration rather than having a spiral progression approach of the Philippine K to 12 Basic Education Program. To bridge the gap of the untaught learning competencies under the content of probability, the researcher utilized project VLOGI to his instructions. Explicitly, this study sought to answer the following questions; 1. What is the students' performance in the pre-test for those exposed to the traditional method and project VLOGI? 2. Is there a marked difference in students' performance in the pre- test between those disclosed in the conventional teaching and project VLOGI? 3. What is the students' performance in the post-test for those exposed to the traditional method and project VLOGI? and 4. Is there a significant difference in students' performance in the post-test between those disclosed in the conventional teaching and project VLOGI?. The researcher's intervention, named project VLOGI, was inspired by videoblogging (Vlog), which is the new blogging trend for digital natives in the contemporary time. Currently, Vlog has a lot to offer in an educational setting. In the current situations, Vlogs may consider as support instructional materials in blended learning modalities for instruction. This videoblogging has a richer web experience than conventional text blogging since it integrates movies, sound, still images, and text, increasing the information – and potential emotions – shared with users (Kusumaningrum and Rahkmanina, 2017). Videoblogging activities can meet today's students' needs surrounded by these highly dynamic and interactive technologies (Baran, 2007). Furthermore, in some research, using videos as a learning media in mathematics improves students' motivation to learn, their comprehension and interpretation of the lesson, and their achievement (Lalian, 2019). The researcher used the experimental research design in his study. The researcher made VLOGs with all the learning competencies under the mathematical content of probability were anchored from the DepEd's Curriculum Guide (2016) of the Philippines. The two (2) randomly selected classes out of the six (6) heterogeneous-classes in school were the study respondents; 1. the control group or the group exposed in the Conventional Method of teaching, and 2. the group exposed in an approach where project VLOGI introduced was the experimental group. Utilizing the 20-item ready-made questioners taken from the DepEd Learners Module in Mathematics 8 (2013) served as the research instruments before and after the interventions. The invited expert panel of evaluators was there to examine the content validity of the construct. The data were obtained and tabulated for statistical treatment using the pre-test scores compared to all respondents' post-test scores. The researcher used the means, standard deviations, and the independent sample t-test using the SPSS tool to analyze and interpret the outcomes. The study results showed that both groups had started with the same performance level before the implemented intervention. Fortunately, there was a significant improvement in the learners' scores observed using project VLOGI than in Conventional Method in teaching after the conducted intervention with a medium effect

size of comparison by Cohen's (1992). Thus, utilization of project VLOGI may awaken students' interest and may augment teacher's absence in the classroom. Hence, project VLOGI should use as an alternative approach in teaching mathematics, and it is highly recommended to those teachers with uncertain responsibilities because of the ancillary services in school. Moreover, the digital learners performed way better in introducing project VLOGI in their lessons. Likewise, it encouraged students' interest to learn with excitement as they engaged their learning to any social media platforms using this project VLOGI.

Keywords: Project VLOGI, Vlog, Experimental Research, Probability.

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PART 4

PARALLEL SESSION 2 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

Classroom Teachers' Beliefs Regarding The Usage Of Digital Tools in Mathematics Lessons During Covid-19 Process

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COVID-19 has affected humans' lives in various ways. Education is the sector influenced just after health sector (Telli Yamamoto and Altun, 2020). In this system, students, teachers, parents as well as its other dimensions have been affected. Distance education has been put forward as solution for this process. As a result of COVID-19, teachers have adapted their instructional process online and they have been using alternative ways of digital tools.

First of all, distance learning can be defined as a form of education in which learners and the facilitator are physically distant and the learning activity is done through a plan and learning experiences structured via various ways of channels (Saykılı, 2018). Besides, these channels allow interactions between/among learners, facilitator, and educational resources. Distance education is considered as a promising innovation due to its flexible learning environments (Allen et al., 2010). Stone and Springer (2019) also mentioned that distance education process necessitates different approaches and skills than face to face instructional process. Along with the challenges, distance education has benefits like continuation of education of students via various tools like videos, web 2.0 tools, pdfs, etc., attending classes in any place and in any time, reducing relatively financial costs, etc.

The use of digital tools provides new opportunities during the instructional process (Chauhan, 2017). These opportunities are closely related to teachers' skills. This COVID-19 process has posed teachers to make their face to face instructional process online and also has posed teachers to use alternative ways of schooling like teaching by various kinds of digital tools (Eickelmann and Gerick, 2020). As well, this process indicated that most teachers hadn't taught online before (Trust and Whalen, 2020). Hence, they had problems concerning technology usage, pedagogical changes, digital tools, students' needs, etc. As Trust and Whalen (2020) stated only teachers who had experienced technological tools and their usage in their courses were easily adapted to distance learning. This result has been found by Alea et al. (2020), they stated that experienced and IT-specialized teachers deal with the new situation better. Moreover, the study of Artacho et al. (2020) indicated teachers had challenges concerning IT issues. UNESCO (2020) reported that students attended distance learning in very difficult circumstances and even without real teaching or support from their teachers. Although high quality education is the right of all children, both teachers and students were generally unaware of the digital inequality and it is increased after this pandemic process (Hall et al., 2020).

In this study, it was aimed to investigate classroom teachers' beliefs regarding using digital tools in their mathematics lessons during distance education process. In order to achieve this aim; teachers' beliefs regarding their usage level of digital tools in their mathematics lesson and teachers' beliefs regarding their level of competence in using digital tools during their mathematics lessons were gathered.

This study has employed case study approach. In a case study, "how and why" of a phenomena are determined and this method makes a contribution in understanding investigated phenomenon in a holistic and real life context (Yin, 2009). In the current study, classroom teachers' beliefs regarding usage of digital tools in their mathematics lessons was studied in a holistic way in its real life context.

The participants of the current study consisted of 14 classroom teachers. Among the 14 participants, 9 were female and 5 were male. Their teaching experiences were; 3 of them have experience 0-5 years, 8 of them have experience 6-10, and 3 of them have experience 11 or more. All participants were informed verbally, and they were told that participation in any part of the study was voluntary. These participants were selected through convenience sampling method. All participants answered semi-structured interview forms while only two volunteer participants' mathematics lessons were observed.

A semi-structured interview form and an observation form were used. These forms were prepared by the researcher and sent to an expert who had an experience about beliefs, digital tools, and mathematics education. According to his suggestions, the order of the questions was redesigned and some of the questions were eliminated due to the similarities in questions. About the observation form, it includes issues like the type of digital tool, the frequency of the usage of it, the purpose of the usage of it, etc.

The study is in data analysis process. The results will be shared during the conference.

Keywords: Classroom teacher, digital tool, mathematics lesson, belief.

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Analyzing the Teacher's Pedagogical Discourse Through the Theory of Commognition

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We analyze a teacher's pedagogical discourse through implementing a case study methodology using the theory of commognition. The teacher in our research introduced the concept of derivative in upper Secondary Education. Specifically, we focus on finding and categorizing new kinds of routines, complementing the work by Viirman (2015). This allows us to infer some characteristics of the pedagogical discourse in the secondary-tertiary transition.

Keywords: Commognition, Pedagogical Discourse, Routines.

Purpose of the study

The purpose of this study is to complement the work by Viirman (2015) by finding new kinds of routines in the pedagogical discourse of an upper secondary teacher when introducing the concept of derivative. We also intend to compare these routines with those in the university pedagogical discourse (Viirman, 2015). Our research questions are:

- What routines are present in the pedagogical discourse of this teacher?
- What are the similarities and differences between the pedagogical discourse of upper secondary education and university?

Theoretical framework

We use the theory of commognition (Sfard, 2008) in our analysis. It considers thinking as a form of intrapersonal discourse and learning as a change in the discourse. Discourse is characterized by four properties: word use, visual mediators, narratives, and routines. Originally, Sfard (2008) only considers these properties in the mathematical discourse, but other authors, like Viirman (2015), extend them to pedagogical discourse. Here we focus on routines, i.e., repetitive patterns that can be inferred by observing discourse. Viirman (2015) studied university teachers' discourses when introducing the concept of function. He found three categories of routines: *explanation, motivation and question posing routines*, with various subtypes.

Methodology

We have employed a qualitative-interpretative methodology through a case study. Our research data are the video recordings of three class sessions dedicated to the main aspects of the concept of derivative and interviews with the teacher. They were transcribed verbatim. The researchers analyzed data individually, searching for new kinds of pedagogical routines in the teacher's discourse, then they discussed the discrepancies and reach a consensus. The next step would be to contrast with this teacher our interpretations.

Preliminary results

We found examples of new kinds of routines, like the *use of synonyms and paraphrases* (second protocol below), the *use of different types of examples* to construct definitions and the *use of personified language* (first protocol below). The first type of routine mentioned is more frequent in upper secondary education than at university, as academic language is precise, univocal, and centered in the content rather than in students. Also, definitions that are constructed through examples promote inductive learning in contrast with advanced mathematics teaching that promotes deductive learning (Bills et al., 2006). Besides, alienated language is more expected in formal mathematics than personified language (Morgan, 2016).

- *We are going to make this "h" smaller, and now we are here, and we draw the secant line that passes through here and here...*

-*There it has a peak, eh, it is named an angular point in mathematics or breakpoint…*

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Exploring the Introduction to Algebra in Finland, Indonesia, Singapore, Taiwan, and the United States

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This study is aimed to explore the introduction to algebra for elementary students and to analyze how the introduction is organized in the representative elementary mathematics textbooks used in Finland, Indonesia, Singapore, Taiwan, and the United States. This study presents some possible algebraic topics to be taught at elementary schools, and findings showed that the five countries have attempted to introduce some of these topics in their textbooks. More specifically, the introduction to algebra was not merely about the understanding of algebraic concepts and using procedural fluency when dealing with equation manipulations; it has been switched from equation manipulations rules to working on generalization, number patterns, ratios, correlations, variables, tables, graphs, and functions. This study expands on previous studies regarding the analysis of algebraic topics and helps us better understand the possible ways to improve an introduction to algebra for elementary students.

Keywords: algebra, curriculum, comparative studies, early algebra, textbooks.

Introduction

Algebra is the linchpin to success in mathematics because of its foundational role in all areas of mathematics (National Council of Teachers of Mathematics [NCTM], 2000). Although algebra has been included in the elementary school curriculum in several countries, integrating algebra into the early mathematics curriculum is still emerging, little known, and far from consolidation (Carraher & Schliemann, 2007). As a concern, algebra is frequently reported difficult for students through high school (U.S. Department of Education [USDOE], 2008). It was thus suggested that algebra-related topics should be taught to elementary students to deepen their understanding of the nature of algebraic thinking (Christine, 2012). An introduction to algebra for elementary students is highly feasible, and the representational tools can be used to encourage them to express algebraic thinking when solving algebra-related problems (Brizuela & Earnest, 2008; Carraher & Schliemann, 2007).

Research Questions

What are some possible topics of algebra for elementary students? How do the five countries' textbooks introduce these topics? What is the approach used to introduce the algebra topics (i.e., pre-algebra or early algebra approach)?

Theoretical Background

Algebraic thinking comprises three essential skills: using symbols and algebraic relations, utilizing multiple representations (e.g., symbols, graphs, tables, etc.), and formulating generalizations. Kaput (2008) argued that the core of algebraic thinking is using symbols and problem-solving to represent mathematical ideas and generalization. Kilpatrick, Swafford, & Findell (2001) suggested introducing basic algebraic concepts in early elementary grades to lay a foundation for algebra instruction in later years. For instance, in early elementary schools, students may find that they can multiply 15 by 11 mentally by computing 15 10 and adding it to 15 1 when they investigate whole numbers' properties—this indicates that they use the distributive property of multiplication over addition, which contributes to algebraic topics.

Methods

This study analyzed the most popular and widely used textbooks from each of the five countries [more details about the percentage of market share of these textbooks in the corresponding country will be presented at the conference—considering the length of the submission]. This study focuses on developing the possible algebraic topics for elementary students by drawing on the review of the literature (e.g., Carraher & Schliemann, 2007; Kieran et al., 2016; MacGregor, 2001; Xin et al., 2011) and the five countries' curricula and mathematics standards. The developed algebraic topics were then discussed by some experts in the field using Delphi Method to clarify the validity and the feasibility of the topics for elementary students.

Preliminary Results

This study presents some algebraic topics (Table 1) that could be taught at elementary school. Table 2 presents the results concerning the presence of the developed algebraic topics in the textbooks. It can be seen clearly that the teaching of algebra was not merely focused on understanding algebraic concepts and using procedural fluency when dealing with algebraic manipulations. The introduction to algebra could have been switched from equation manipulation rules to working on generalization, number patterns, ratios, correlations, variables, tables, graphs, and functions.

Words count:
From the sections of Introduction to Preliminary Results: 498 words

Table 1
The possible algebraic topics for elementary students

Algebra Topics	Example
Representation of an unknown number using a letter	E = 4; M = 8, so E + M = 12
Simple algebraic expressions	y ± 2, 6 ± y
Interpreting the algebraic expressions	3y as y + y + y or 3 × y
Simplification of algebraic expressions	Mary is 5 years old than her sister Carla. How old is Mary? Algebraic expression: If Carla is C years old, then Mary is C + 5 years old
Evaluation of simple algebraic expressions (substitution)	*5 + x = 12*, if the letter x is replaced or substituted by a number, then the number sentence is either true or false. Students need to evaluate the computational result.
Solving word problems involving algebraic expressions	Hunter used a $20 bill to pay for a CD that cost $11.49. How much change did he get?
Identifying patterns, ratios, and correlations pictorially	□ ○ □ ○ What is the second shape? To continue the pattern, what shape comes next? The students are asked to determine the next number of 2, 4, 8, 16, 32, ...
Simplification of expressions involving fractional coefficients and brackets	a). As part of teacher's day celebration, Mrs. Williams bakes 5a cookies. She gave 8 cookies to each of her students on that day and left with 2a cookies. How many students does Mrs. Williams have? b). Simplify (24 – 6) × 2; ($\frac{1}{2}x$ + 4) – 3 = 2
Simple linear equations and inequalities	Describe and graph the solution set of $x + 3 > 10$ by using a number line.
Representing functions using words, algebraic notation, tables, and graphs	Sara earns $6 per hour. Use a rule, a table, and a graph to find how much Sara earns in $2\frac{1}{2}$ hours.
Translating from one representation to another and using representations to solve problems involving functions	For his birthday, Marc received a piggy bank with one dollar. He saves 2 dollars each week. At the end of the first week, he has 3 dollars; at the end of the second week, he has 5 dollars, and so on. How much Marc would have after Weeks 10, 15, and 25?

Table 2
Algebraic topics covered in the five countries' textbooks

No	Algebra Topics	Countries				
		SNG	**FIN**	**TW**	**USA**	**IDN**
1	Representation of an unknown number using a letter	✔	✔	✔	✔	✔
2	Simple algebraic expressions	✔	✔	✔	✔	✔
3	Interpreting the algebraic expressions	✔	✔	✔	✔	
4	Simplification of algebraic expressions	✔	✔	✔	✔	✔
5	Evaluation of simple algebraic expressions (substitution)	✔	✔	✔	✔	
6	Solving word problems involving algebraic expressions	✔	✔	✔	✔	✔
7	Identifying patterns, ratios, and correlations pictorially	✔	✔	✔		✔
8	Simplification of expressions involving fractional coefficients and brackets	✔	✔	✔	✔	
9	Simple linear equations and inequalities	✔	✔	✔	✔	✔
10	Representing functions using words, algebraic notation, tables, and graphs				✔	
11	Translating from one representation to another and using representations to solve problems involving functions				✔	
	Total	**81.82%**	**81.82%**	**81.82%**	**90.91%**	**54.55%**

Note: SIN (Singapore), FIN (Finland), TW (Taiwan), USA (the United States), IDN (Indonesia)

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PART 4

PARALLEL SESSION 3 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

Misconceptions and Solution Offers on Algebraic Expressions: A Literature Review

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In general, algebra, one of the most important branches of mathematics in which the properties of numbers, shapes, and multiplicities and the relationship between them are examined, can be expressed as a generalized form of arithmetic. In the current Turkish dictionary; Algebra is defined as "the branch of mathematics that establishes general connections between positive and negative real numbers and quantities with the help of letters that replace them" (Turkish Language Association [TDK], 2013). Kieran (1992) defines algebra as a discipline that symbolizes general numerical relationships and operations on mathematical structures. Algebra representing the transition from operations between numbers and multiplicities to relationships between variables corresponding to numbers is one of the subject areas that students have difficulties, especially at the secondary school level. Kaput (1999) points out that the main source of this difficulty is the teaching of algebra at the secondary school level without being associated with daily life. The importance of algebra and the differences in the source of the difficulties have led to define the aim of the study as to examine the literature regarding the difficulties experienced by the students concerning algebraic expressions, their misconceptions, and solutions. The model of the research was determined as a literature review; A total of 33 studies consisting of articles, theses, books and papers were analyzed through document analysis. According to the general evaluation of the reviewed studies; it has been observed that researches were generally conducted on secondary and high school students.

When the misconceptions about algebraic expressions are examined it has been observed that the main source of the misconceptions is the concept of variable (Çavuş Erdem, 2013; Luka M. 2013); is arithmetic (Mathaba, 2019); is transition from arithmetic to variable and symbols (Chua, Shahrill and Tan, 2015). The idea that mathematics consists only of numbers also makes letters meaningless in mathematics (Yıldızhan and Şengül, 2017; Şimşek, 2017; Akbulut, 2018). Misconceptions related to the use of algebraic expressions are encountered (Ay, 2017). The thought that the value of the letter is 1 when the coefficient of the letters is 1 is among the misconceptions encountered the letters are arranged according to the place value notation or that they form a pattern (Yıldızhan and Şengül, 2017; Akkaya and Durmuş, 2015; Akbulut, 2018). Some students think that the given letter will be an abbreviation of any object. It is thought that the variable expression can only be x and cannot take the other letters. In addition, some students accept that there are letters in mathematics and think that they do not act as numbers (Yıldızhan and Şengül, 2017). Some misconceptions arise from associating algebraic expressions with equations (Akkaya and Durmuş, 2006; Çavuş Erdem, 2013; Şimşek and Soylu, 2018) There is an opinion that any two different letters that are equal cannot be equal (Çakmak Gürel and Okur, 2017). There is an opinion among students that the equal (=) sign will indicate a direction and always give the result of only one operation and

will indicate a result (Çakmak Gürel and Okur, 2017; Akkaya and Durmuş, 2006; Booth, Mcginn, Barbieri and Young, 2017; Booth and Koedinger, 2008). Egodawatte (2011), in his research with high school students, stated that the concept of variables and the concept of equals in the equation create great problems for students. It has been seen that when multiplying in algebraic expressions, operations are performed without considering the parentheses (Demirören, 2019). While writing a statement given in the form of a sentence in a mathematical form, some mistakes were encountered about the side to write the unknown (variable), the place where it will be used and bracketing (Şimşek and Soylu, 2018; AL-Rababaha, Yew and Meng, 2020; Ung, Eng and Khium, 2019). There are prerequisite topics (functions, proportions and operations, numbers and operations, equality, modeling) for students' transition to algebra, and misconceptions are related to prerequisite areas. When the students were given a sentence containing addition and multiplication and were asked to write the expression algebraically, it was observed that very few students were able to do it correctly and others made a mistake (Bush, 2011). It was seen that some students took the given variable x as a multiplication sign and operated in that way (Şimşek and Soylu, 2018; Yıldızhan and Şengül, 2017). There are squared and cubed notations as if multiplying while adding x expressions (Şimşek, 2017; Saputro, Suryadi, Rosjanuardi and Kartasasmita, 2018; Mulungye, O‘Connor and Ndethiu, 2016). Some students find results by operating between different variables that are not similar to each other (Şimşek and Soylu, 2018; Saputro, Suryadi, Rosjanuardi and Kartasasmita, 2018; Irawati, Zubainur and Ali, 2018; Mulungye, O‘Connor and Ndethiu, 2016; AL-Rababaha, Yew and Meng, 2020). In algebraic expressions, mistakes are seen when adding them to an equation of their own and finding the result of the variable (Şimşek and Soylu, 2018). In problem solving, it was observed that students ignore the components of the problem and directly dealt with the given variables (Yalvaç, 2019). It was observed that the students knew x as a universal variable and used it to answer the questions even though they were not sure about this variable. In addition, it was observed that the students had the misconception that x and y cannot be multiplied by adapting the rule of addition of similar terms to multiplication. (Tiwari and Fatima, 2019). There is a misconception of accepting the identities given in the form of (a+b)n=an+ bn as correct (Shahrill and Tan, 2015; Mulungye, O‘Connor and Ndethiu, 2016; AL-Rababaha, Yew, Meng, 2020; Ung, Eng, Khium, 2019). Sarımanoğlu (2019) stated that the reasons for the misconception are inability to operate in arithmetic, thinking that variables are used only for natural numbers, and ignoring letters. While simplifying fractions, errors such a+ba=b and a+xb+x= ab about variables are encountered (AL-Rababaha, Yew, Meng, 2020).
As a result of the research, it was seen that the studies conducted were similar to each other. It was observed that the main misconception was that students had difficulty in understanding the concept of variable, which is the basic of the concept of algebra, and therefore they made various mistakes. The transition from arithmetic to algebra is of great importance for students to avoid misconceptions in algebraic expressions. At this step, students start to make the transition from arithmetic expressions to generalization towards algebra. To prevent the formation of these misconceptions, it is recommended to be careful in the operation of this step and to include connections with daily life in concept teaching.

Keywords: Algebra, Algebraic expression, Misconceptions, Solution offers.

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Development of Self-Efficacy Scale of Differentiated Instruction for Teachers

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Each individual has different characteristics from each other. These individual differences affect learning situations. Therefore, teaching methods that respond to individual differences should be used. One of these teaching methods is differentiated instruction. Differentiated instruction can be defined as a strategy by which teachers provide different avenues to students' learning in response to variation in readiness, interests, and learning profiles (Tomlinson 2001). In differentiated instruction based on students' readiness levels, interests and learning profiles, content, process, product, learning environment and assessment can be differentiated in a way that can respond to these principles and in accordance with the structure of the course (Chapman ve King, 2005; Tomlinson, 2014). After the teacher identifies these differences, he should organize and plan the teaching environment in order to ensure the student's meaningful learning. The teacher should teach by using more than one teaching material. It should determine the learning levels at the end of the process. When attention is paid to differentiated teaching, it is seen that teachers have great responsibilities.

The goal of the study was to develop a scale to determine teachers' self-efficacy levels about differentiated teaching. For this purpose, firstly the literature was searched. This process applied differentiated teaching education by interviewing five teachers who are continuing their education in learning education. The 61-item draft form was examined by experts. In this context, firstly, the items in the item pool were presented to 2 experts in assessment and evaluation, 1 expert in program development in education and 1 language education expert. Experts in assessment and evaluation and curriculum development evaluated each item in the draft form as "appropriate", "corrected" and "not suitable" according to the scale's purpose. The language expert, on the other hand, expressed his opinion by examining its grammatical structure, language structure and comprehensibility. Corrections were made to all three items from experts.

The sample of this study consists of teachers working in various provinces of Turkey. Before proceeding to the analysis process, the data were enumerated and transferred to the computer environment, and during the scale, exploratory analysis and exploratory analysis were conducted. The exploratory factor analysis scale consists of 27 items and six factors. KMO (Kaiser-Meyer-Olkin) value of the scale was calculated as .89, Bartlett's sphericity test result was calculated as $x^2 = 3657.88$ and it was found to be significant at .01 level. The factors of the scale are named as "Teaching Process \ Product, Content, Learning Profile, Readiness, Assessment and Learning Environment in Terms of Affective Dimension". The factor loads of the structure are .76-.51 in the 1st factor, .84-.70 in the 2nd factor, .79-.70 in the 3rd factor, .76-.59 in the 4th factor, .84-.68 and 6 in the 5th factor. In the factor loads are between .79 and .66 as well. It was concluded that the model of fit indices obtained from the confirmatory analysis was sufficient. It was seen that the Cronbach Alpha coefficient of .92 was determined to determine the interior architecture of the scale. Among these results, it was concluded that the differentiated response self-efficacy scale for teachers was completed and a reliable measurement tool.

Keywords: Scale development, differentiated instruction, self-efficacy, teacher

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An Examination of the Misconceptions about the Circle and the Disk in the Context of the Literature of Mathematics Education

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Learning geometry is at the center of its contribution to understanding topics such as any architectural or engineering design, mathematics and physics course. Furthermore, learning geometry provides an opportunity to develop mathematically reasoning skills alongside math subjects (Association of Mathematics Teacher Educator [AMTE], 2017). Geometry consisting of shapes, properties of shapes, transformations, location and visualization is the study of shapes and space including two-dimensional (2D) and three-dimensional (3D) spaces (Van de Walle, Karp ve Bay-Williams, 2012, pp.400). Even though all objects in the world have shapes, 2D geometry first focuses on shapes with basic properties such as circles, triangles, rectangles, squares, rhombuses, trapezoids, hexagons, and other polygons. Most objects humans make can be modeled with such shapes, especially when they divide or create such shapes into more complex shapes (AMTE, 2017). Geometric shapes and objects are introduced and named to students at primary school level based on their visual features as a whole in accordance with Van Hiele's geometric thinking levels. In other words, geometric shapes are classified according to their appearance rather than their features (Ünlü ve Ertekin, 2020). The number of π and the concepts of the circle and the disk are included in the 6 and 7th grades in the current mathematics curriculum (Ministry of National Education [MoNE], 2018). Considering the sequential and cumulative nature of mathematics and geometry, it is inevitable that the lack of conceptual learning about the circle will directly affect the later acquired geometric knowledge (Aksu, 2020). From this point of view, the aim of the research was determined as the examination of the studies conducted on the misconceptions encountered about the circle and the disk. The model of the research was determined as a literature review; A total of 31 studies consisting of articles, theses, books and papers were analyzed through document analysis. According to the general evaluation of the studies examined; it is possible to say that the studies on the subject have been carried out starting from many past years and are still being done and the subject is still up-to-date. Since the topic of the circle is included in many classroom curricula, studies cover different grade levels. The samples of the investigated studies consist of elementary mathematics teacher and candidates, primary school teacher candidates and students. The findings obtained as a result of the analysis of the studies examined about the misconceptions about the circle and the disk are generally as follows: It was seen that mathematics teachers used the number of π as a fraction (rational number) to provide ease of calculation. Besides, it was determined that they could not establish a relationship between radian and degree and could not make any explanation about radian. (Erdem and Man, 2018). It is common for mathematics teachers candidates to perceive the number of π as a unit, dividing the radius to the circumference or proportioning the area to the perimeter while calculating (Tavşan and Pusmaz, 2020; Öztürk and Işık, 2020). In the context of definitions related to concepts, errors are seen especially in distinguishing circle, disk, spheres, geometric shapes and bodies from each other. Also, there are some mistakes about the definitions of concepts such as chord, tangent, central angle, inscribed angle, diameter, radius (Kıymaz, Kartal and Morkoyunlu, 2020; Gerez Cantimer and Şengül, 2017; Akuysal, 2007; Çetin and Dane, 2004; Demir, 2019; Kemankaşlı and Özsoy, 2004;

Kara, 2021). When the primary school teacher candidates were asked about the definition of the circle, there were very few candidates who made the conceptual definition; It was observed that they made non-conceptual and misleading statements such as "*hollow shape with circumference*", "*shape with 360 degree angle*", "*shape with circumference and area*". For the disk, it was seen that they defined it as "*a solid shape with area and volume*" (Aydoğdu İskenderoğlu and Akşan Kılıçaslan, 2021).

It is clear that students produce solutions based on keywords, without examining the information given in the text of the question; It is seen that they did this both while solving the question and explaining the reason. (Akuysal, 2007; Metikasari, Mardiyana and Triyanto, 2019; Demir, 2019; Çelik Görgüt, 2020). When asked about the circumference of the disk, some students say that " *disk has no circumference*". There are also students who say the area formula with circle-area association (Bekdemir, 2012). It is observed that 8th grade students have difficulty in associating the circle with other shapes (Wijayanti and Abadi, 2019; Çelik Görgüt, 2020). There are some misconceptions about the concept of tangent in circle and disk in understanding the incircle of the triangle (Waluyo, Muchyidin and Kusmanto, 2019). Inability to grasp the relationship between diameter and radius in 6th grade students (Kara, 2021); while describing the concept image belonging to the circle, errors due to not being able to define the concept were observed (Yenilmez and Demirhan, 2013). Similarly, misconceptions have been observed to confuse the concepts of diameter and radius, circumference and diameter, circumference and area (The Center for Educational Testing and Evaluation [CETE], 2015). In a study with 5th grade students (Özerbaş and Kaygusuz, 2012), it was reported that the concept that students misunderstood the most about the concepts of circle, disk, diameter, radius and center was the concept of radius, and the concept that they made the least misunderstanding was the concept of center.

In another study, it was misunderstood that the circumference cannot be measured because the disk and similar shapes are not linear (Güven Akdeniz and Argün, 2019). 4th grade students were interested in the fact that the circle and the disk were only a round shape and they confused these two concepts (Akkaya, 2018). It has been determined that high school students have difficulty in proving deductive geometric theorems (Ndlovu and Mji, 2012). It can be stated that the reason for the misconceptions encountered is definitions in general. It is seen that the misconceptions reported in the studies are similar to each other. Emphasizing that the use of daily life problems in the teaching of the aforementioned concepts will reduce students' mistakes and increase their interest in the lesson; it is recommended to use daily life problems in teaching, to know the levels of students, to use real models, to include activities, and to use dynamic geometry software (Demir, 2019; Göktaş, 2019; Topuz and Birgin, 2020; Öztürk and Işık, 2020). From this point of view, pre-lesson preparation by teachers and using concrete materials in the lesson, starting the lesson with a remarkable material, students' learning about their concerns about the subject and carrying out preparatory activities to eliminate those concerns can be counted as preventions that can be taken to reduce errors and misconceptions.

Keywords: Circle, Disk, Misconceptions, Solution offers.

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SOCIAL MEET UP (USA EST 1:20 - 2:20 PM / TR 20:20 - 21:20)

DAY 3 – MAY 28, 2021

KEYNOTE SPEAKER – PROF. DR. HULYA GUR

"Reflections of the Pandemic on Distance Education: An Investigation in the Context of STEM and Flipped Learning"

Prof. Dr. Hülya Gür

Balikesir University, Turkey

(17:00, Turkey) (10:00AM, Eastern)

PART 5

PARALLEL SESSION 1 (USA EST 11:00 AM – 12:00 PM / TR 18:00-19:00)

An In-Service Primary Teacher's Responses to Unexpected Student Questions About Measurement of Length

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The purpose of this study is to examine an in-service primary teacher's responses to students' unexpected ideas and questions during lessons on the measurement of length. For this purpose, the study tries to answer the following research questions: What unexpected moments occur during an in-service primary teacher's lessons on measurement of length? and How does the teacher respond to these unexpected moments? To answer these research questions, we draw on the Knowledge Quartet (Rowland, 2013), a theoretical framework for the analysis of mathematical knowledge in teaching. In particular, we draw on the contributory codes of the Contingency dimension of the Knowledge Quartet. The study was located in a school in Turkey, where the in-service primary teacher-participant taught a fourth-grade class with 36 students. She taught nine 40-minute lessons to cover the objectives regarding the measurement of length in the curriculum. These lessons were observed and video-recorded by a researcher, who made field notes in order to identify the students' unexpected ideas and questions. Ten unexpected moments were identified in the observed lessons, and relevant contributory codes of the Contingency dimension of the Knowledge Quartet framework (Rowland, 2013) were assigned to each of these moments. Semi-structured interviews were conducted with the teacher after each lesson, in order to interpret and understand the reasons for her responses to these contingent moments. Three unexpected moments resulting from students' questions in the nine lessons were identified for further analysis. The nature of teacher's response to each of these events was classified as one of three response-types identified by Rowland et al. (2009). The first of these three contingent moments arose from a student's question about conversion between metric units of length, when the teacher's response was coded as 'acknowledging but sidelining' the question. The second student question was also related to unit-conversion. Although one student offered a helpful suggestion it was also acknowledged but sidelined. The third of these unexpected moments was triggered by a student's question about recording lengths in cm and mm. In this case the teacher offered the student's question to the whole class: her response-type in this case was to 'acknowledge and incorporate' the student's idea. In order to respond effectively to students' ideas and questions, teachers need to try to understand what students are suggesting or asking (Jacobs & Philipp, 2004). The reason for not being able to make use of some of the students' questions may be that the teacher did not really consider how best to respond. Teachers can take wrong answers as an opportunity to move students forward to correct answers. If the teacher had paused to consider her responses, she could have discovered how to build upon their questions, considering the objectives of the lesson (Sherin, Jacobs, and Philipp, 2011). In this study, ten unexpected moments were identified in the teacher's length-measurement instruction, three of which resulted from students' questions. These questions were mostly related to conversions between metric units. Considering the second research question, it was found that the teacher's responses characterized two of the types identified by Rowland et al. (2009): to acknowledge but sideline; and to acknowledge and incorporate. Our approach to the analysis of this case could be applied to other cases, to assist the development of mathematics teaching.

Keywords: teachers, measurement, contingency, knowledge

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Examination of Classroom Teacher Candidates' Critical Thinking Skills through Advertisements

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Thinking is the process of deciding what to believe or what to do by making sense of the current situation as an action that keeps the brain functioning continuously (Cüceloğlu, 1999). Thinking, which is a mental product, realizes thanks to the interactions between elements that exist in the mind, and if adaptation, reasoning or judgment is to be made, it reaches the result by activating affective inputs in mental processes (Jones, 2019). Environmental factors, education level and social environment are important factors in the development of an individual's thinking skills (Özdemir, 2005). It is divided into many different types in terms of thinking, purpose and skills. For example; creative thinking, critical thinking, analytical thinking, metacognitive thinking, divergent thinking, convergent thinking, lateral thinking, algorithmic thinking and critical thinking (Çiftçi, 2017). According to NACE (2017), employers rated the need for critical thinking/problem solving as the most needed competency for career readiness. During the last two decades students at higher education are being more exposed to the concept of critical thinking as a way to improve not only their professional skills, but their personal competencies as members of a global community (Altuve, 2010; Crenshaw, Hale, & Harper, 2011; Facione, 2013; Moore, 2013; Villarini, 2003). Halpern (2014) warns that in our era, in which a myriad of knowledge can be easily accessed at one click, it is important to teach students to be critical and effective thinkers. Critical thinking is usually related to other skills that are considered key in the 21st century in students' learning process, with stakeholders, and in everyone's family life: metacognition, motivation, and creativity (Moeti, Mgawi, & Mealosi, 2017). Critical thinking is a competence student need in their personal and professional lives. Therefore, universities should do their best to include this in their teaching programs and classroom practice. Since there is no clear definition of critical thinking competence and many new methodologies need to be developed to develop this skill, it seems to be an issue that educators should focus on for many years (Bezanilla, et al., 2019). This study was conducted on the classroom teacher candidates' levels of using critical thinking skills through advertisements. This work was carried out with 14 teacher candidates in 3rd grade, the classroom education department of a university in South Anatolia region in Turkey. Before the data were collected, a questionnaire study was carried out on how to reflect their critical thinking skills to prospective teachers in the most comfortable way. This survey included topics such as social problems, covid-19 process, cultural values, our education life, personal development, individual needs, global problems, communication problems and advertisements. Since it was concluded that more than half of the students participating in the study chose the subject of advertising, this study was conducted on advertisements. The opinions and critical approaches of the advertisements given to the pre-service teachers to watch and interpret were analyzed. When the results were examined, it was concluded that the advertisements of the teacher candidates were generally gathered in the themes such as violation of ethical values, products that do not reflect the truth, subliminal messages, gender inequality, and women's body preemptive of products. In general, it can be said that pre-service teachers can look at advertisements critically, but some of them have very superficial implications. The reason for the pre-service teachers' such shallow answers may be that they have not received any thinking training throughout their education. For this, at least after high school education, it can be suggested that the courses with the content of thinking education should be included in the curriculum.

Keywords: Critical Thinking, Higher Education, Teacher Candidates, Advertisements

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Analysis of the Interest of Astronomy for the Mathematical Training of Primary School Teachers

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Providing teachers with the skills and confidence necessary to teach effectively and in a multidisciplinary way is much more complex than simply explaining knowledge of scientific content.

The purpose of this work is to present an instructive intervention for students of the Degree in Primary Education on the science of the celestial bodies, with some reference to the pedagogical content of the knowledge of astronomy. A concept-based multidisciplinary approach is adopted for the development of curricular activities and the content of the activities places special emphasis on:

(1) spatial learning and spatial thinking, which are considered central and fundamental to astronomical education, and

(2) the alternation between the terrestrial and spatial perspectives of the shape, position and movement of the celestial bodies.

Understanding the solar system involves a number of related conceptual areas that are clearly important in relation to children's existing frameworks. They include the understanding of the spatial aspects of the Earth, the conception of day and night, the seasonal change, etc. Astronomy is a scientific discipline about which individuals have collected information through their personal experiences with nature since childhood (Trumper, R., 2003).

Montoya, Jódar, Uclés, Moreno and Arcas (2009) bring to Primary Education classrooms a globalization of learning that has as a common thread the study of planets, satellites and stars involving all areas. Vílchez-González and Ramos-Tamajón (2015) offer results with Primary Education students in relation to the study of the Sun-Earth-Moon system and the conceptual change in the interpretation of everyday phenomena through different methodologies.

The study begins with a bibliographic review of literature related to the key terms: mathematics, astronomy, primary education. The innovation that arises must be justified according to the contents programmed in the different courses of the university degree and by the contents of the official school curriculum; the contents collected at both levels will be analyzed (in later works).

The methodology, participants and materials are described according to the following stages:

- Bibliographic review.
- Analysis of the official school curriculum in Primary Education in relation to the contents related to Astronomy.
- Analysis of the contents of the Mathematics subjects studied in the Primary Education Degree (at the University of Murcia), selection of topics in which introducing activities related to astronomy may be interested. The teaching guides corresponding are consulted.
- Assessment of the interest in introducing Astronomy activities and their approach. They are oriented to the practical work of the students of the Degree in Primary Education in their Mathematics and Didactics subjects. They are made on the basis of free access virtual resources.

Keywords: Didactics of Mathematics, Astronomy, Degree in Primary Education**.**

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PARALLEL SESSION 2 (USA EST 11:00 AM – 12:00 PM / TR 18:00-19:00)

Analysis of How Desmos Activities Potentially Aid Students in Learning Absolute Value Inequality

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Technology might improve teaching and learning in a way that a traditional learning might not. For instance, it facilitates dynamicity by which paper and pencil classrooms cannot offer. However, due to the abundance of digital technologies, determining which one is suitable for our teaching and learning purposes is challenging. Among many platforms, Desmos has the potentials to provide instructional materials for learning absolute value inequality. To discover the opportunities by which teachers can benefit from Desmos activities, we analyzed the affordances and possible challenges of using five classroom activities designed by Desmos under a bundle called ‘inequalities’ (Desmos, 2019).

This study employed the content analysis method (Krippendorff, 2004). We analyzed the instructional materials provided by Desmos and developed a framework for doing so. We adopted a framework for employed in Remillard, Harris, and Agodini’s study (2014). Remillard et al. (2014) stated that Opportunity to Learn (OTL) is divided into three dimensions: (a) mathematical emphasis, (b) instructional approach, and (c) supports for teachers (Remillard et al., 2014, p. 739). In this particular report, we focus on the first dimension.

Our analysis suggested that every activity is at doing mathematics level. None of the five Desmos activities are in lower-level demand (Stein & Lane, 1996). Several questions are not necessarily on the high-level demand level (Stein & Lane, 1996)., but as a whole, the task is the high-level demand task. For instance, the ‘Inequalities on the Number Line’ is a higher-level demand task because the instruction does not require students to use algorithmic thinking. Students can complete the questions without knowing any particular mathematical procedure. The activity begins with students dragging a point in line representing ‘less than’ three. This activity does not require students to use any specific rule because they can just drag the point. Moreover, the path of a solution is not clear, and thus, considerable cognitive efforts are needed in solving the problem. They also need to make connections among verbal, symbolic, and graphical representation. Besides, the last activity, ‘which one doesn’t belong?’ requires creativity and mathematical argument.

By a regular routine, we mean repetitive activities before the main task. So, we consider ‘warmup’ activities in the point collector and point collector as an example of a regular routine. The ‘warmup’ activities will prepare students to solve the main tasks, ‘challenges,’ requiring students to write inequalities so the produced graph can maximize the points. Moreover, the ‘point collector’ and ‘point collector: lines’ activities aim to develop students’ procedural fluency to some degree. In completing the two tasks, students need to flexibly use their understanding of linear and absolute value inequalities. In doing so, students need to really understand what inequality represents geometrically or graphically. Next, one of the students’ difficulties which is well addressed, is the dominance of the integers (Almog & Ilany, 2012). This difficulty means that students might think of integers as a solution for inequality. We argue that students can avoid this conception because they experienced dealing with several points and possibly infinitely many points that can be represented by an inequality.

The Desmos tasks are helpful for introducing the idea of absolute value inequality, the details of inequality signs, and the connection among various representations: verbal, symbolic, and graphical representations. Moreover, the absence of a particular procedure introduced in the Desmos resonates with Sierpinska et al. (2011). They argued that students would develop their meanings based on their meaning of absolute value inequality visually. The findings also showed that five Desmos activities could promote elaboration, conjecturing, and generalization, which was highly valued by, for instance, Balomenou et al. (2017).

Keywords: Desmos, Absolute Value Inequality

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Formation of Self-Control Skills in Schoolchildren

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In this work, we consider examples of solving situations that indicate the effectiveness of the listed recommendations.
1) Check the answer based on common sense.
2) A rough estimate often helps when solving word problems.
3) Calculations or identity transformations can often be verified by performing the inverse action or transformation.
4) If the task required a factorization, then the check can becarry out a simple multiplication.
5) The roots of an equation or a system of equations are easy to substitute into the condition and conduct a direct verification.
6) When solving quadratic equations, mistakes from time to time are made practically all students. Therefore, it is necessary to check the obtained roots using Vieta's theorem.
7) Text problems are effectively checked by "running" the received answer to the text of the problem.

Keywords: Mistakes, skill, check, recommendation, transformation, theorem, self-control.

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Assessing a Teaching and Learning Elementary School Mathematics Course with Mathematical Quality of Instruction (MQI) Framework, a 'Modified' Self Study

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Keywords: Self Study, MQI, Professonal Development, Teaching Elementary PSTs.

Purpose of the study

Self-study has been defined and applied by many researchers. The definition that most closely reflects the design of this study: "Intentional, a systematic inquiry by a practitioner into her own practice" (Dinkelman, 2003). Many student teachers enter teacher education programs expecting to be able to be taught how to teach (Britzman, 1991; Hayward, 1997; Richardson, 1996). However, teacher education programs do not fully meet the expectations and preservice teachers need to do different researches and studies while improving their teaching (Loughran, 2005). Therefore, teacher and teacher educator candidates should use self-study to improve their professional development. In this study, the author used modified self-study for assessing his lecture's mathematical quality.

Research Questions

- How is the mathematical quality of the lesson according to the MQI framework?
- What are the researchers' shortcomings and mistakes, how can improve the mathematical quality of the lesson and teaching?

Theoretical framework or perspectives

In this self-study, mathematical quality of instruction (MQI) framework was used as a theoretical framework. To evaluate the self-study, two critical friends and the researcher analyzed the lesson using the MQI Four Main Dimensions (Charalambous, 2018) and Whole Lesson Assessment Rubrics (Hill 2014).

Methodology

Self-study as a methodology has received much greater attention in the teacher-education research literature (Zeichner, 1999). The importance of self-study research has been demonstrated by many studies. Self-study research typically utilizes a wide variety of qualitative methodologies and seeks to answer a range of questions about teacher education practices (Goodell, 2006; Zeichner, 1999). In this study, the researher used the two rubric of MQI framework for the analysis of this study. According to Harvard University Center for Education Policy Research, the MQI framework has an important place in teacher education for teachers to evaluate and develop teachers. MQI framework allows observers to evaluate the quality of the mathematics in instruction, captures the nature and quality of the mathematical content available to students as expressed in teacher-student, teacher-content, and student-content interactions, and provides separate teacher scores for different dimensions of the mathematical work teachers do.

In this study, the author prepared an hour lesson plan in the "Teaching and Learning Elementary School Mathematics" course, which was taught to elementary preservice teachers. The courses were recorded with video recording. Two critical friends were involved in the evaluation of the lecture.

Results

For the first research question, it is seen that the scores given by the critical friends researcher give for the mathematical quality of my lecture are high. According to the scores, it can be

said that the mathematical quality of the lesson is sufficient. However, although It was got high scores in general, It is noticed some deficiencies for some codes.
For the second research question, the shortcomings It is noticed in these items enabled the researcher to reach the conclusion of the second research question. In order to improve the mathematical quality of the lesson, the author has to correct the mistakes and deficiencies which he made. He has to make the students more active during the lesson plan and during the lesson. It may be beneficial to leave more flexibility in the plans that cover the whole course in order to include students in the lesson.

Conclusion

In general, It is realized that the lesson was mathematically qualified and the researcher would like to examine the changes in these codes in the next self-studies, paying attention to the missing features. In many of the self-study studies, It is noticed that researchers used long-term studies, such as a few months, a semester, or a year. In the next period, the researcher will plan the self-study research to be longer researches.

Many frameworks may use as theoretical frameworks for self-study researches. That's why researchers believe working with different frameworks will have different benefits. The self and professional improvement of teachers and teacher educators should never end. Every new research and practice will enable researchers to become better teachers and teacher educators.

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PART 6

PARALLEL SESSION 1 (USA EST 12:10-1:10 PM / TR 19:10-20:10

Approach of Science Teachers to Errors in General Mathematics Course

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In order to go further than avoid mistakes and make learning more meaningful, a positive perspective on mistakes should be developed. Instructional errors in mathematics education can take many different forms, often numerical. Boaler (2015) suggests that creating an environment in which students are comfortable dealing with errors is beneficial for learning mathematics. Such an environment depends not only on how the teacher deals with student error, but also on how they handle their own mistakes. In this study, prospective teachers' approaches to errors in questions about limit, derivative, integral and asymptotes were determined as a case. Perspectives against this situation were examined in detail in line with the answers given by the candidates to the questions of "what, how, why" and presented to the reader (Yin, 1984).
Participants of the study consisted of 60 teacher candidates studying in the third grade of the Science Education Program of a university in Central Anatolia. Criterion sampling was used in the study. In the study, the fact that the prospective teachers took General Mathematics I-II courses made us think that they might have a different point of view against errors, and individuals who are suitable for this criterion were chosen. The pre-service teachers participating in the study were coded as M1, M2,…, M43 and the data were presented using these codes. In the study, the data collection tool is a knowledge test consisting of six open-ended teachers' responses were calculated and the expressions of reason were analyzed.
In line with the findings obtained, it was observed that the candidates could not detect questions and one closed-ended question answered as true or false. Two of the open-ended test questions given in the knowledge test are limit, one is derivative, two are integral; All true-false type questions consist of questions that help to measure the necessary information with asymptotes. All open-ended questions consist of questions that contain incorrectly resolved questions and question the determination of the error and the reasons for them. The knowledge test prepared as a data collection tool was presented to prospective teachers in writing. There is no specific time limitation. The pre-service teachers were asked to identify the errors in the solutions made and explain the reason for this error with its reasons. In addition, candidates who thought the solution was wrong were also asked to make the solutions they thought were correct.
In this study, the data obtained in line with the answers given by the pre-service teachers to the knowledge test, which was used as a data collection tool, were coded according to their ability to identify the errors in the solutions of the questions and explain the reasons for these errors, and classified under predetermined categories in line with the purpose of the study. The analyzed data were presented in tables and interpreted.
Due to the characteristics of the questions in the test applied to pre-service mathematics teachers, the test data were classified as being able to find errors in the solutions of the questions related to the subject and explain the reasons correctly. Then, the frequencies of the data obtained from the pre-service the error in most of the questions given or they detected it incorrectly. It has been determined that most of the candidates who detected the error wrong or correct made the wrong solution.

Keywords*:* error, approach to mistakes, teacher education

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Analysing Conceptual and Procedural Knowledge in Rational Number Density Understanding

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Previous research has shown that learners have difficulties in understanding the dense structure of rational numbers. In the present study, we focused on the domain of density performing a cross-sectional study with 953 primary and secondary school students (from 5th to 10th grade) with the objective to determine profiles according to students' answers to conceptual and procedural items. Furthermore, we are interested on finding relationships between students' performances on procedural and conceptual items. Conceptual items focus on asking the students how many numbers there are in between two rational numbers. Procedural items ask students to write a number between two pseudo-consecutive rational numbers. A *TwoStep Cluster Analysis* was performed identifying 13 profiles (stages in rational number understanding). In the present study we focused on the correct profile in order to identify relationships between students' performances on procedural and conceptual items. Results seem to show that those students who were able to write a number between two fractions and between two decimals, were able to answer correctly that there is an infinite number of numbers between them. Nevertheless, those students who knew that there is an infinite number of numbers, were not able to write a number between them, especially in the case of fractions.

Keywords: natural number bias, rational number, density, primary and secondary education.

Introduction

The rational number concept plays a key role in students' mathematical development (Behr et al., 1983). However, understanding rational numbers has been described as a student's stumbling block (Carpenter et al., 1993). Previous research has pointed out the interference of natural numbers as a main explanation of students' difficulties in understanding rational numbers (Fischbein et al., 1985). This overreliance on natural number properties is named as *natural number bias* (Van Dooren et al., 2015).

In the present study, we focused on the domain of density. Previous research has shown that understanding the density of rational numbers (there is an infinite number of numbers between any two rational numbers) is complex for primary and secondary school students (Merenluoto & Lehtinen, 2002). Some students believe that there are no numbers between two rational numbers, or there is a finite number of numbers. For instance, students consider that there is only one number (1/3) between 1/2 and 1/4 (Merenluoto & Lehtinen, 2004) or that between the "pseudo-consecutive" decimal numbers, 0.59 and 0.60, it is not possible to find other numbers (Moss & Case, 1999). Furthermore, difficulties in understanding the dense structure of rational numbers are also related to the fact that rational numbers can be represented as both, fractions and decimals. Previous research has shown that students sometimes treat fractions and decimal numbers as unrelated sets of numbers, rather than interchangeable representations of the same numbers (Carpenter et al., 1993).

During the last decades, research has tried to identify students' intermediate stages in understanding rational number density (Vamvakoussi et al., 2004, 2007, 2010, 2011). These studies have used conceptual items, asking students how many numbers there are in between two rational numbers. We contribute to this line of research by adding items focused more on a "procedural knowledge", asking students to write a number between two pseudo-consecutive rational numbers. In this study we perform a cross-sectional study with a large sample of primary and secondary school students (from 5th to 10th grade) with the objective to determine profiles according to students' answers to conceptual and procedural items. Furthermore, we are interested on finding relationships between students' performances on procedural and conceptual items.

Method

Participants were 953 Spanish primary and secondary school students, who answered six conceptual items where they had to answer how many numbers there were between two fractions or between two decimals, and three procedural items where they had to write a number between two fractions or two decimals. The items were presented in a randomised order in eight different versions. We performed a *TwoStep Cluster Analysis* (Chiu et al., 2001), in order to identify 13 profiles (stages in understanding rational number density). In procedural items, we found six profiles: *Naïve*, *Correct decimals fraction naïve*, *Fraction consecutive*, *Correct decimals fraction consecutive*, *Almost Correct*, and *Correct*. In conceptual items, we found seven profiles: *Naïve*, *Correct decimals fraction naïve*, *Decimal finiters*, *Finiters*, *Decimal Differencers*, *Correct*, and *Rest*. Moreover, to examine possible relationships between procedural and conceptual items, we focused on each profile identifying how students had solved each type of item. In this study, we focused on the correct profile.

Results

Focusing on the correct profile, students who correctly wrote a number between two fractions and between two decimals, correctly answered that between two fractions and between two decimals there is an infinite number of numbers. However, those students who correctly answered that between two fractions and between two decimals there is an infinite number of numbers, had difficulties writing a number between two fractions and between two decimals. Furthermore, most of the students correctly wrote a number between two decimal numbers, but had difficulties in writing a number between two fractions.

Conclusion and Discussion

Results seem to show that those students who had procedural knowledge about rational number density, that is, were able to write a number between two fractions and between two decimals, were able to answer correctly that there is an infinite number of numbers between them. Nevertheless, those students who had conceptual knowledge, that is, they knew that there is an infinite number of numbers, were not able to write a number between them, especially in the case of fractions.

Acknowledgements

This research was carried out with the support of the project PROMETEO/2017/135 from Conselleria d'Educació, Investigació, Cultura i Esport (Generalitat Valenciana, Spain), and the predoctoral grant from the University of Alicante (UAFPU2018-035), and the postdoctoral grant (I-PI 69-20).

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An Investigation of Primary School Teachers' Opinions and Skills of Classifying Illustrations Accompanying Problems in Mathematics Textbooks

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When looking at the nature of learning, it is stated that learning proceeds through three stages: the enactive, the iconic and the symbolic (Bruner, 1961). It is known that visuals have a mediating function between theory and practice in the learning process. Illustrations are commonly used in many areas of our lives, especially in educational settings. Illustrations used in books are helpful for students to understand verbal and textual expressions (Yige, 2010, p. 106). Learning performance has been shown to increase when individuals learn with text and illustrations, rather than just learning with text (Lindner, Eitel, Strobel, & Köller, 2017, p. 91). Illustrations are widely used in textbooks to explain information, concepts and problems more clearly. Illustrations are seen as a tool to support reflection and convey mathematical ideas. (Elia & Philippou, 2004). Teachers frequently use illustrations to explain information and concepts more clearly and in solving/posing problems. Therefore we thought it is necessary to investigate educational illustrations from teachers' point of view. For this reason, the purpose of this research is to determine the primary school teachers' opinions on the use of illustrations in mathematics teaching. The research was conducted with the case study design, one of the qualitative research designs. Six primary school teachers were interviewed to get their opinions. As the data collection tool, a teacher interview form which consists of two stages was used. At the first stage, the teachers were asked 11 verbal semi-structured questions. In the second stage, teachers were asked to interpret and classify the illustrations that accompany the selected 9 problems found in primary mathematics textbooks of different grades. From the statements obtained from the teachers, it was concluded that all teachers benefited from the illustrations and encouraged their students to use them. In addition, it was observed that the basic knowledge of the teachers about the illustrations was good and they were able to classify the illustrations. Before the teachers saw the illustration accompanying the problems, they were able to classify the illustrations only according to their purposes similar to Levin (1981). After teachers saw these illustrations, they classified them in two groups as in Dewolf, Van Dooren, & Verschaffel (2015): according to the state of using an illustration for solution and according to its formal structure. Although the teachers stated that they benefited from the illustrations, thought that the illustrations in the textbooks were insufficient, and thus, they often needed to use different illustrations out of textbooks for explaining a subject or solving a problem. As a result of the research, it is considered that it would be appropriate to train students and teachers on the use of illustrations as a recommendation for improving mathematics education.

Keywords: Mathematics education, mathematics textbook, problem solving, illustration classification.

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An Overview of History of Mathematics Studies in the Context of Mathematics Education: A Meta-Synthesis Study

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It is assumed that the idea of integrating the history of mathematics with mathematics education and using it effectively in the curriculum and textbooks has been promoted since the 19th century (Clark et al., 2016). When the literature is examined, there are lots of studies about the history of mathematics in the context of mathematics education, and in many countries, the history of mathematics class is included curriculum (Koyuncu & Özdemir, 2020). In the study conducted by Baki & Bütüner (2018), meta-synthesis research of the history of mathematics studies conducted between 2000-2015 was handled. However, there are limited studies related to the researches on the history of mathematics between 2016-2020. The purpose of this research is to analyze the history of mathematics studies in the context of mathematics education between 2016-2020 by the meta-synthesis method and to present the type of tendency in this field. The following research question is asked: How do studies on the history of mathematics show distribution in purposes, samples, data collection tools, methods, results, and publication types? In the study; SAGE Premier Journals, ELSEVIER Scopus, SpringerLink, Taylor & Francis, JSTOR, EBSCOhost-ERIC, Google Scholar, ProQuest Dissertations&Theses, Wiley, TÜBİTAK ULAKBİM Dergipark and Higher Education National Thesis Center databases were used. In the research, a total of 47 studies made up of 38 articles, 7 master's theses, and 2 doctoral dissertations, which were published between the years of 2016-2020 and chosen through a purposeful sampling method, were analyzed. Obtained data were interpreted depending on the frequency and illustrated with tables and graphs. Most of the studies aimed to investigate changes in students' levels of achievement, attitude, belief, motivation, self-efficacy, mental calculation development, and mathematical thinking. Articles constitute an important part of the studies. Most of the qualitative studies have consisted of case studies and document reviews. The studies were mostly conducted with middle school students, and the most used data collection tools were interview forms, documents, scales, and questionnaires. As a result of the research, some suggestions were made to researchers and practitioners who will study the history of mathematics.

Keywords: History of Mathematics, Mathematics Education, Meta-Synthesis

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Exploring In-Service Teachers' Lesson Plans to Promote Improper Fractions

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Keywords: In-service teachers, pedagogical content knowledge, improper fractions

Introduction

Pedagogical Content Knowledge (PCK), which refers to interpretation and transformation of subject matter knowledge, includes understanding students' conceptions (Schulman 1987). Fraction knowledge such as improper fractions is difficult to learn and teach (Hackenberg, 2007; Kerslake, 1986; Newton, 2008) because teachers have limited content knowledge and pedagogical content knowledge (e.g., understanding students' conception about fractions). Therefore, most researchers recognized pre-service and in-service teachers' lack of content knowledge (e.g., Tirosh, 2000; Newton, 2008; Putra,2019) and pedagogical content knowledge (e.g., Naiser et al. 2004; Isiksal & Cakiroglu, 2011) about fractions. For example, Naiser et al. (2004) observed teachers' pedagogical content knowledge over 4 months and described ways to improve teaching fractions, i.e., understand students' initial concepts, using manipulatives. However, little research has been done on pre-service teachers' task design skills on complex fractions concepts such as improper fractions. In this study, we will investigate pre-service teachers' tasks to promote students' conception of improper fractions.

Some researchers explored students' construction of improper fractions (e.g., Hackenberg, 2007; Steffe, 2002). Steffee (2002) argued that an iterative fraction schema is not sufficient to independently produce improper fractions; therefore, splitting is an essential multiplicative operation to construct improper fractions. Splitting operation is accompanied by interiorizing three levels of units (Steffe, 2002). However, Hackenberg (2007) showed that students can have splitting operations without interiorizing three levels of units. Therefore, teachers can be able to design different mathematical tasks for students who interiorized three levels of units than for students who did not interiorize three levels of units (Hackenberg, 2007). In this study, we prompt PSTs to design a lesson plan that includes two different tasks for students who did/did not interiorize three levels of units to promote. Therefore, we will explore the following research question:

1. How do in-service teachers design a lesson plan to foster students to produce improper fractions? (a) for students who interiorized three levels of thinking, (b) for students who did not interiorize three levels of thinking.

There are two main stages in the design of this research. These stages are the design of the Interviews and Lesson Plans. The study will start with interviews in order to analyze the content knowledge and previous learning experiences of the in-service teachers. Later, two different student types will be explained to the teachers by the researcher with documents and presentations. Teachers who have learned these two different types of students will be asked to prepare a lesson plan based on the learning goal on improper fractions by taking different students into consideration. The validity of the mathematics activities and teaching strategies prepared in the lesson plan will be evaluated for different students and it will be evaluated how the strategies used in the lesson plan are affected by the teachers' previous learning experiences and content knowledge.

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Family Members' Perspective on STEM Education: How aware are they?

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Since many of the problems that we face in our daily life requires the integration of STEM concepts to solve them, there are national calls to educate students in STEM fields. (Wang, H., Moore, T. J., Roehrig, G. H., & Park, M. S., 2011). At the same time, the recent reforms in the field of education highlight the importance of the STEM education approach in individual and social life (Akarsu, M, Okur Akçay, N, Elmas, R, 2020). STEM education also enables students to develop their 21st century skills, such as creative thinking, innovation, design, entrepreneurship, being an effective part of teamwork, taking responsibility in the learning process, being able to analyze correctly, scientific literacy, technological literacy by integrating different disciplines. With the break of the COVID-19 pandemic, teaching the STEM process to students started to become harder. As we all know, in the pandemic process everyone has to stay at their homes, and the schools are no longer available for providing an education. With this development, the sustainability of education is also interrupted. From now on, parents have a great responsibility to ensure the sustainability of education and not to deprive the student of developing these abilities, and families' perspectives on this issue play an important role. Therefore, in this study, we will examine in the following research question: What is the perspective of family members towards STEM education?

In this study, we will use qualitative case study methodology (Strauss, A., & Corbin, J. M., 1990; Yıldırım, A., & Şimşek, H., 2005). In the experimental study group, 2 different groups of 3 people will be formed. The group includes families with children in primary school. In the first group, at least one family member has to graduate from a university. In the second group, none of the family members has to graduate from a university. In determining the working groups, providing of connection will be made via e-mail and volunteers will be selected among them. We will use clinical interviews to collect data via Zoom, due to the pandemic conditions. In addition to this, interviewer will fill out an observation form. The transcripted video and the observation form will be analyzed by using coding process. This research study is now under-design. With the development of the process, it will be done.

Keywords: STEM Education, family, perspective, sustainability in education

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PANEL 2: STEM EDUCATIONAL APPROACH (USA EST 1:20-2:20 PM / TR 20:20-21:20)

Moderator

Dr. Lane Bloome, Culver-Stockton College, USA

Associate Professor Dionne Cross Francis, University of North Carolina, USA

Dionne Cross Francis has a B.A. in mathematics from the University of the West Indies, Jamaica, and a Ph.D. in educational psychology from the University of Georgia. Her research interests include investigating the relationships among psychological constructs such as beliefs, identity and emotions, and how the interplay between these constructs influence teachers' instructional decision-making prior to and during the act of teaching mathematics. Cross Francis is the recipient of the K-12 Promotion of Education Award from the 2014 Women of Color STEM Conference for educators with a demonstrated commitment to enhancing STEM career opportunities for women and minorities through promotion of STEM education programs and exemplary teaching and outreach activities.

Associate Professor John Somers

John Somers is an associate professor of Teacher Education and coordinator of graduate programs at the University of Indianapolis. John completed his doctoral degree in Educational Leadership and Curriculum and Instruction at Indiana University, Bloomington, IN. He teaches courses in STEM, engineering, and special education for elementary education candidates and graduate students. He has served as PI on several national and regional grants including Next Generation
Communities of Mathematical Practice; Using Apps, Animation, and Games to Explore Children's Mathematical Thinking; Constructing a Virtual Community of Mathematical Practice amongst Teacher Candidates, Practicing Teachers & Teacher Educators; Creating a Mathematics Game Lab; and Creating and Co-constructing Accessible Makerspaces.

Associate Professor Rıdvan Elmas

Ridvan Elmas is an associate professor in Science Education Department at Afyon Kocatepe University, Turkey. He graduated as a chemistry teacher with a master's degree in an integrated teacher education program. He completed his Ph.D. in chemical education at Middle East Technical University in Ankara, Turkey, in 2012. While carrying out his Ph.D., he was a visiting researcher at the University of Utrecht FISME, The Netherlands, for six months. He worked with Prof. Dr. Albert Pilot on designing contextual teaching and learning environments. From 2012 to 2013, he worked as an Education Strategies Expert in a private company that creates an online adaptive learning management system for high school students. He was appointed as an assistant professor of science education at Afyon Kocatepe University in 2013. Between 2017-2018 he performed his first post-doctoral studies with Prof. Dr. George Bodner on inquiry-based learning and STEM education at Purdue University. Besides, he worked as a senior post-doctoral researcher on a STEM Education Project at Charles University Prague, The Czech Republic, between 2018-2019. He has several roles as a writer to several high school chemistry textbooks to as a researcher and PI in several research projects funded by The Scientific and Technological Research Council of Turkey or EU. Since then, he has constantly been working on designing STEM Modules, Learning in context, and Science curriculum.

Assistant Professor Amber Simpson

Amber Simpson joined the Department of Teaching, Learning, and Educational Leadership in 2017. She received her undergraduate degree in Mathematics, Secondary Education from East Tennessee State University, and her Master's degree in Curriculum and Instruction and Educational Specialist degree in Education Administration and Supervision from Lincoln Memorial University. Simpson spent five years as a high school mathematics teacher in Tennessee before returning to Clemson University to receive her PhD in Curriculum and Instruction, Mathematics Education. She is interested in examining maker education in adolescent learning of STEM-related practice skills as well as ways to engage families within the process of making. Simpson is interested in understanding one's STEM identity: specifically female identification or disidentification in STEM-related degrees and careers. She is interested in exploring how one's STEM identity is shaped within various learning experiences including formal; informal and out-of-school learning experiences.

DAY 4 – MAY 29, 2021

KEYNOTE SPEAKER - PROF. DR. LIEVEN VERSCHAFFEL

"Four decades of mathematical word problem solving research (1980-2020): Lessons learnt by an active participant."

Prof. Dr. Lieven Verschaffel

Catholic University of Leuven, Belgium

(17:00, Turkey) (10:00AM, Eastern)

PART 7

PARALLEL SESSION 1 (USA EST 11:00 AM -12:00 PM / TR 18:00-19:00)

Potential of Usage of Astrolabes in Mathematics Education

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This study aims to examine the mathematical contexts that emerge during the use of the astrolabe in terms of mathematics.What is an Astrolabe? Used in various astronomical measurements, for example, to determine the positions of the Sun, Moon, planets and stars, to determine local times, and to better understand and solve some mathematical problems. Therefore, we can say that the astrolabe is both a calculation and an observation tool. The astrolabe has functions such as rangefinder, timer, compass and calculator. The combination of these four functions results in a computer-like instrument (Bilim Kutusu,2021). Data were collected by using the semi-structured interview method and the case study model was used. The participants of the study are 10 mathematics and 4 science teachers. Without any time limitation, the participants were provided with the conditions in which everyone could easily express their thoughts individually, the answers were made in the form of face-to-face interviews in the online environment, and the questions in the semi-structured form were used in this process, and the answers given by the content analysis method were also examined. The study group was determined through purposeful random sampling in a school in Gaziantep province with the effect of epidemic conditions. The interview method aimed at obtaining in-depth information was used (Gay, 1987). In these interviews, the questions were prepared beforehand and directed to the interviewee in a certain order and order and they were allowed to answer as they wanted (Batu, 2000; Gay, Mills, & Airasian, 2006). The data obtained as a result of these interviews were analyzed by content analysis method. According to the results of the research, it is thought that the astrolabe is directly related to some fields of

education in the mathematics program and indirectly with others, and its use will contribute to permanent learning in mathematics and science lessons.

Keywords: Inquiry skills, mathematics teaching, astrolabe.

* This work is produced from the master thesis titled " Examination of Mathematical Contexts Arising During the Use of Astrolabes in Terms of Mathematics curriculum ".

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A Comparative Study of Trigonometry Standards in Turkey, Zambia, and the United States

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Knowledge and Skills for University Success (KSUS) reflect the essential knowledge and skills in six disciplines among them English, social sciences, and mathematics, which are helpful for success in college-level courses in the United States (Conley, 2003). Trigonometry is an important topic to enhance students' problem solving, reasoning, and visual representation skills (Tuna, 2013; Fi, 2003). Therefore, KSUS involved trigonometry as an essential topic to comprehend college-level courses, i.e., "to understand periodicity and recognize graphs of periodic functions, especially the trigonometric functions" (Conley, 2003, p. 34). Since the KSUS is highly aligned with International Baccalaureate (IB) standards (Conley & Ward, 2009), trigonometry is important for all students worldwide.

Only 22% of the students who took the ACT test reached the college-readiness level in mathematics, which includes trigonometry standards. A possible reason for the low readiness could be the intended and implemented curriculum (Schmidt et al., 2001). Therefore, researchers were more likely to compare the United States' mathematical standards with high-achieving countries' standards to identify what is happening in other nations (e.g., Porter et al., 2011; Schmidt et al., 2005). However, there is a need to compare the United States' high school mathematical standards with not only high-achieving countries but also other countries in the world because of the mutual benefits for the countries involved. In this study, we investigated similarities and differences among three countries' trigonometry curriculum standards (the United States Common Core State Standards, Turkey's and Zambia's standards.

We analyzed cognitive expectations by focusing on verbs of the trigonometry standards based on Webb's Depth of Knowledge framework (DOK) (Webb, 2007). The framework has four levels, which reflect the complexity of the analysis. We used Hess's (2013) guide to decide the level of verbs. For example, *working* with special angles refers to level two, and *drawing* graphs for functions refers to level three. Then, we used a direct analytic approach to compare a set of standards with another set of standards (Tran et al., 2016). Preliminary findings show that all three countries' standards have similar trigonometric topics while each country invented to teach the same standards at different levels. For example, the three countries have standards relevant to drawing trigonometric functions. Turkey and Zambia have standards with a lower-level verb (to draw) while the United States' standard emphasized a higher-level verb (to model). The United States did not have any standards at level 1 (Recall and Reproduction) while Turkey had (14%) and Zambia (19%). Likewise, compared with Turkey and Zambia, the United States (69%) was more likely to emphasize higher order thinking skills at level 3 and level 4. Turkey (43%) was less likely to support higher order thinking skills than Zambia (51%). The qualitative analysis showed that all three standards study trigonometric ratios in the right-angled triangles and use these to solve problems. CCSSM started from similarity, thus calling understanding side ratios in a triangle to draw definitions of these trigonometric ratios. In contrast, the Zambian syllabus went straight into the use of these ratios to calculate sides. Turkey, on the other hand, talked about solving right-angled triangle problems using Pythagoras' theorem. The CCSSM objective taught procedure while Turkey and Zambia's interest was in algorithms. The limitation of the study was exploring the standards only. Assigning verbs might not always be sufficient to assign DOK levels because a variety of resources play roles in teaching. Therefore, future studies would extend this study by analyzing other resources such as textbooks with the standards.

Keywords: Standards, Curriculum, Policy, Comparative

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Using the Mathematical Contexts of Sundials in Mathematics Education

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This study aims to examine the mathematical contexts that emerge during the use of sundials in terms of mathematics education. The aim of this study is to find correlations between the working principles of Sundials and the achievements of the mathematics curriculum. Sundials are astronomical devices that show the time during the day with the help of a shadow. Sundials contain mathematical contexts in learning areas such as geometry and measurement, from the construction stage to its use. This study was conducted to evaluate these contexts in terms of the mathematics curriculum. The study group was determined by simple random sampling among the mathematics teachers working in various provinces with the effect of pandemic conditions. In this framework, interviews were held with 15 mathematics teachers who are actually working in the in schools under the national ministry of education in Turkey. The research data were collected using a semi-structured opinion form. Then, they interviewed with the researcher to obtain detailed information. Due to the pandemic conditions, some of these interviews were conducted online, some by phone and some face to face. The purpose of using the interview method in the research is to ask for detailed information on the data (Gay, 1987). In these interviews, the questions prepared beforehand were directed to the interviewee in a certain order and order, and they were allowed to give answers as they wanted (Batu, 2000; Gay, Mills, & Airasian, 2006). The data obtained as a result of these interviews were analyzed using the inductive analysis technique. According to the results of the research obtained, it has been concluded that sundials are directly related to some fields of education in the mathematics program and indirectly with others, and its use will be beneficial in concretizing mathematics. It has been determined that sundials contain useful contents in many fields such as similarity in triangles, circles, arcs, measuring time, measuring length, and trigonometry. The analysis processes of the study are ongoing. A detailed presentation will be made within the scope of the declaration.

Keywords: Interdisciplinary association, mathematics teaching, sundials.

* This work is produced from the master thesis titled "Examination of Mathematical Contexts Arising During the Use of Sundial in Terms of Mathematics curriculum".

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PARALLEL SESSION 2 (USA EST 11:00 AM - 12:00 PM / TR 18:00-19:00)

Diagnostic Classification Models to Compare Proportional Reasoning of Turkish and Spanish Middle School Students

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Proportional reasoning (Lesh et al., 1988) is related to concepts such as multiplicative structures (Vergnaud, 1983) and functional modeling (De Bock et al., 2017). It includes simple direct (Karplus et al., 1983), inverse, and multiple proportion situations (Arican, 2018). Ratio and rate are two fundamental concepts (Tourniaire & Pulos, 1985) that can be used to distinguish semantic types of problems (Lamon, 1993). Proportionality tasks are usually classified into missing-value and comparison problems (Cramer & Post, 1993; Martínez-Juste et al., 2017, 2019). To avoid the 'illusion of linearity', to work in parallel with nonproportional situations is necessary (Van Dooren et al., 2008). Moreover, different representations can be considered in proportional problems (Bayazit, 2013).
Diagnostic classification models (DCM) are a family of psychometric models designed for diagnostic assessment purpose (Rupp et al., 2010). Instead of measuring an overall mathematics ability, as unidimensional item response theory models do (Bradshaw & Templin, 2014), DCM break mathematics down into attributes and classify examinees as master or nonmaster of them offering a diagnostic feedback (Bradshaw et al., 2014). There are three forms of DCMs: compensatory, noncompensatory, and general. In the compensatory models, nonmastery of some of attributes can be compensated by the mastery of the remaining attributes. On the other hand, in the noncompensatory models, nonmastery of a required attribute cannot be compensated by the mastery of the other required attributes (Ravand & Robitzsch, 2015). Finally, general models allow both compensatory and noncompensatory relationships (Templin & Bradshaw, 2014).
DCMs are widely used statistical tools which are useful to investigate individuals' understanding of a certain subject (Arican & Kuzu, 2020). DCMs can also be used to perform comparisons between different student populations (Dogan & Tatsuoka, 2008).
In this study, we applied a general DCM, log-linear cognitive diagnostic model (LCDM) (Henson et al., 2009), to compare Spanish and Turkish middle school students' mastery of four core cognitive skills (i.e., attributes) related to proportional reasoning and to provide a diagnostic assessment of the students' strengths and weaknesses. Moreover, we interpreted the observed differences according to characteristics of the test items (context, type of proportional task, and representations).
Our test was designed from an LCDM perspective. It included 22 multiple-choice items and aimed to measure students' mastery of four core skills related to proportional reasoning. These attributes are defined as follows: Understanding the concept of a ratio and determining the value of a quantity in a given ratio (A1); Recognizing and solving daily-life problems involving directly (A2) or inversely (A3) proportional relationships and nonproportional relationships (A4).

The sample consisted of 596 students: 282 Turkish seventh grade students and 314 Spanish eighth grade students. All the Turkish students were enrolled at the same high achieving middle school. Spanish students came from seven middle schools from a province in the north-east of Spain. According to both curricula, the students were supposed to have the required knowledge before taking the test.

The results indicated that in both countries, each item discriminated well between masters and nonmasters of the attributes. However, we found some statistically significant differences between the two samples. While Spanish students had the most difficulty in mastering A1, Turkish students performed worse in mastering A4. Furthermore, we found that the students in two countries are distributed among attribute profiles differently. In comparison to Spanish sample, Turkish sample mostly consisted of either low or high performing students and placed among fewer attribute profiles.

Spanish students' low performance in attribute A1 could be a consequence of the poor attention given in Spanish textbooks to conceptual aspects of proportionality (Martínez-Juste et al., 2017). Moreover, the Turkish students' overuse of directly proportional strategies (greater than among Spanish students) is an example of the 'illusion of linearity'. The inspection of the results in each item provides more information about these differences. The uniform distribution Spanish students among the different master profiles is consistent with PISA 2018 results (OECD, 2019), where few Spanish students were detected in high and low profiles. We think that our work can be used to design a wider comparative study including qualitative data that lead to a better understanding of the differences identified (Cai et al.,2016).

Keywords: Proportional reasoning, comparative study, middle school, diagnostic model.

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Investigation of Preservice Elementary Mathematics Teachers' Understanding Logical Structures of the Propositions

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Considering the axiomatic structure of mathematics, one of the most important components of this structure is definitely propositions. Evaluating the truth and falsity of a simple proposition is required complex cognitive activity (Epp, 2003). Therefore, one of the reasons that students have difficulty in the proving process is related to their understanding of the logical structure of the proposition to be proved (Epp, 2003; Moore 1994; Selden and Selden, 1995). Using connectives (not, and, or, if … then, if and only if) and quantifiers (universal and existential) properly and negating a proposition are important to understand a proposition's logical structure. For this reason, the aim of this study is to investigate pre-service elementary mathematics teachers' understanding logical structures of the propositions. At first a test will be designed in order to choose the participants of the study. In the test, propositions in various logical structures (some of them in mother-tongue and the other in mathematical language) will be given and asked to determine the truth value of each propositions and to negate these propositions. After analysis of the test, the participants of the study will be chosen by using criterion sampling method. The clinical interviews will be held with the chosen participants about test items. The data will be analyzed qualitative methods and will be interpreted using APOS (action-process-object-schema) theory.

Keywords: Proposition, connectives, quantifiers, negation

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Indonesians' Mathematics Tutors' Struggles During Covid-19 Era

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As argued by Adedoyin and Soykan (2020), we are now facing a growing demand for using technology in mathematics classrooms primarily caused by the unprecedented Covid-19 pandemics era. In this situation, most teachers worldwide, including Indonesia, have been forced to employ remote learning practices without proper training and enough experience in doing so (see Mailizar et al., 2020). Aliyyah et al. (2020) also stated that some of the challenges confronted by teachers were technical issues, student circumstances, the participation of students, and online teaching experience. Their research focused on the challenges faced by teachers in an online classroom setting. Meanwhile, we will focus on mathematics tutor teachers by which we argue that they are affected economically. Unlike school teachers, in a tutoring setting, tutors economically depend mainly on how many students they are working with. With the current conditions, their job may be affected negatively or positively. So, in this study, we aim to understand another spectrum of teachers' welfare, e.g., how they manage their job and economically survive during the pandemic. Hearing their voices might reveal their struggles affected by larger socio-economic dynamicity but also can inform us how they adjust their approach during this time (Johns & Mills, 2021). We propose three research questions for this study. What challenges did Indonesian mathematics tutor teachers face during the pandemic economically? How did Indonesian mathematics tutor teachers adapt to the learning transformation and preserve their job during the pandemic? This study uses a qualitative research method. The chosen method will allow us to get rich data and do elaboration. The research data will be collected by semi-structured interviews in identifying mathematics tutors' struggles. In our case study, we will choose five mathematics tutor teachers as our participants voluntarily. After data collection, the data will be analyzed based on the result of previous studies that describe the impact of COVID-19 on teachers. This research is expected to convey how Indonesian mathematics tutor teachers deal with challenges during COVID-19.

Keywords: Teachers' Struggles, Covid-19, Socio-Economic

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PART 8

PARALLEL SESSION 1 (USA EST 12:10-1:10 PM / TR 19:10-20:10)

The New Type of Problem; Math-Ap-Roblem(S) and an Overview of the Posed Problems by Mathematically Talented Students on These Problems

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Purpose of the study

In this study, the qualities and the features of "**M**ath**AP**roblems" [**MAPs**] (Mathematics Problems with Apparatus) which were posed by mathematically talented students are examined in detail.

Mathematically gifted students have a tendency to mathematizing the environment which can be explained as that they usually pose problems for their selves during daily routines (Krutetskii, 1976). In this study, students experienced a new approach of problem posing which they had not experienced before. In this leading study, it is aimed to reveal problem posing characteristics of mathematically talented students to open gateway for how to use **M**ath**AP**roblems to facilitate gifted learning.

This is a part of the study (Arikan, 2019) in which mathematically talented students' approaches to MAPs in terms of problem solving, mathematically thinking characteristics of gifted students and problem posing were examined. Within the study, students were firstly introduced and solved the MAPs then, they were asked to pose MAPs. In the cohesive study (Arikan, 2019) it is found that MAPs facilitate mathematically gifted students to use mathematically gifted thinking characteristics such as *organizing materials, looking for patterns and relations, thinking with symbols, generalizing, flexible thinking, inverse thinking, economical thinking, and mathematical memory* (Diezzman, 2002; Greenes, 1981; Krutetskii, 1976; Straker, 1983: Wagner & Zimmermann, 1986).

Theorical perspective

Apparatus are concrete objects which are designed mainly for problem solving and problem posing. They facilitate to develop contents which require higher order thinking, and reasoning for more than one gain, field or skill. Apparatus can be easily manipulated such as turning, holding, and rotating. They can be evaluated within the scope of manipulatives. Besides, they are the specialized version of manipulatives in terms of structure, aim, content, and usage (Ugurel, 2019). MAPs are the problems which cannot be solved by using the related apparatus (Ugurel, 2019).

Problem posing can be defined as generating new problems or restructuring existing problems (Silver, 1994; Kontorovich, Koichu, Leikin & Berman, 2012; Stoyanova & Ellerton, 1996; Stoyanova, 2000). Posing problems gives opportunities to students to view a standardized content clearer and to develop deeper understanding, in turn, enhances exploring and forming new perspectives (Brown & Walter, 2005; Stoyanova, 2000).

Methodology

The study was designed as a qualitative case study (Cresswell, 2007). Participants were eighteen 7th, 8th and 9th grade students who were chosen from Science and Arts Centers (BILSEM) who were on mathematics study groups. They were chosen based on the views of mathematics teachers, who work in Science and Arts Center, on students' mathematics talents.

After solving ten MAPs on four different apparatus, students were asked to pose two math problems on two apparatus which were assigned by the researcher among the four apparatus students used in MAPs solving. Students were given the apparatus and free problem posing (Stoyanova, 2000) was expected. Students were asked to think aloud while posing problems. Moreover, they were asked to write and explain the problems they posed after they had generated.

Video records were taken during the problem posing process. Video records were transcripted (Patton, 2002) by the researcher including screenshots of the constructs which students formed with apparatus while posing problems. Data analysis was conducted through qualitative content (transcripts, students' writings) analysis.

The researcher developed the evaluation rubric for posing problems based on the literature on mathematically gifted students and problem posing (Diezzman, 2002; Kontorovich, Koichu, Leikin & Berman, 2012; Krutetskii, 1976; Kulm, 1994; Silver & Cai, 2005; Ugurel, 2019; Van Harpen & Sriraman, 2013; Yuan & Sriraman, 2011).

Results

The posed problems are examined in terms of quality (being a MAP) and the features (originality, having awareness of solution) based on the rubric developed by the researcher.

Students posed twenty-one problems, eight from the one of the apparatus, thirteen from the other. Two of the problems were not evaluated since they did not provide the conditions for being a problem. Each participant had posed at least one problem.

It is seen that students can pose qualified MAPs but the rate of the original ones and the ones they had awareness of solutions were limited.

Discussion and conclusion

The results showed that students can pose qualified MAPs which demonstrate students conceptualized MAPs.

The results of the study are consistent with the results of the previous studies researchers examined mathematically talented and gifted students' posing math problems. They also found that the rate of original problems posed by students were low (Yuan & Sriraman, 2011; Van Harpen & Sriraman, 2013).

Ugurel (2019) states that posing problem with apparatus operates different than ordinary problem posing, because of that a problem set up with apparatus can be relatively easy for the poser, while it can be a complex process for the solver. It is supported with the finding of the study that the rate of the posed problems which students had awareness of the solutions was limited and students tried to solve their own problems after they posed in certain problems.

To conclude, posing problems has a great importance on learning mathematics, to improve understanding and thinking (Brown & Walter, 2005; Silver, 1994; Stoyanova, 2000), and using apparatus provides students with broader perspective to pose problems which they have not experienced before (Arikan, 2019; Ugurel, 2019).

Keywords: Manipulatives, MathAProblems (MAPs), Problem solving, Talented student, Math Problems.

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The Stages of Cognitive Activity of Junior High School Students through Interaction of Thinking in Solving Geometry Problems

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This study describes the stages of students' cognitive activity through interaction activities to think in solving math problems, especially geometry. This research was conducted on 5 students who were discussing geometry problems. The discussion activities were recorded audio-visual and the conversation transcripts were made. The results showed that the activities of the five students in solving problems began with high-ability students to provide explanations about how to answer the questions given. Other students listen to and sometimes respond to explanations given by high-ability students. The next activity is that they jointly discuss and help each other to find solutions to the problems given by submitting questions or explanations between one student and another. This activity is continued until a solution is found to be decided together and then written on each answer sheet. After they wrote down their respective answers, it turned out that the answers were written in different forms and some still saw the answers from their friends. So, the understanding in deciding problem solving by a group of students is not necessarily the same in representing it in writing.

Keywords: Thinking Interaction, Problems Solving

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Developing Mathematical Knowledge for Teaching Teachers: A Self-Study about Referent Units

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Even though some research has been conducted to examine teachers' knowledge of fractional concepts and procedures (e.g., Ball, 1990, Copur-Gencturk & Burak Olmez, 2020; Izsák, 2008; Newton, 2008; Olanoff, Lo, & Tobias, 2014), few research studies have examined mathematics teacher educators' knowledge of fractional concepts and procedures.

Purpose of the Study and Research Questions

The purpose of this self-study is to contribute to bridging this gap. Specifically, I will self-examine my knowledge of referent units and its development. To this end, this self-study will address the following two research questions.

1) What is my current knowledge of referent units?
2) How did I develop this knowledge?

Brief Literature Review

According to Ball, Thames, & Phelps (2008), mathematical knowledge for teaching is the "knowledge needed to carry out the work of teaching mathematics" (p. 395). One of the topics included on the school mathematical curriculum is the concept of fraction. Understanding fractions and operations involving fractions requires to have an understanding of the referent units (Philipp & Hawthorne, 2015). The referent unit is the unit number to which the fraction refers. While there have been some studies that have investigated teachers' understanding of referent units (e.g., Copur-Gencturk & Burak Olmez, 2020; Izsák, Jacobson, & Bradshaw, 2019; Lee, 2017), a review of the literature revealed that little is known about mathematics teacher educators' knowledge of referent units.

Methodology

According to LaBoskey (2004), 'the aim for teacher educators engaged in self-study is to better understand, facilitate, and articulate the teaching-learning process". As noted by Suazo-Flores et al. (2019), self-studies have increasingly becoming modes of inquiry in mathematics teacher education research. To better understand mathematics teacher educators' knowledge of referent units, I conduct a self-study research of my current knowledge of referent units and how I developed this knowledge.

Keywords: Mathematics teacher educators' knowledge

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The Use of Information and Communication Technologies in Teaching Geometry

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In the modern world, there is a rapid development of information and communication technologies (ICT). It is no longer possible to imagine a modern person and in almost all areas of activity it is impossible to do without their application. In the same way, ICT is increasingly being used in the field of education. In this connection, the goal of education is to educate a person adapted to the new conditions.

The uniqueness of the use of ICTs is that they can be used at all stages of the learning process: when explaining new material; when fixing and repeating; when final control.

Keywords: geometry education, dynamic geometry, İCT, virtual teaching.

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Role of ICT for Better Mathematics Teaching

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The objective of this study is to explore the role of the application of ICT tools in Mathematics teaching. Learning and conversation technologies (ICT) are an integral part of daily life, including the teaching-learning process. For a long time, the role of mathematics was reduced to the purely academic domain. But at present, the role of mathematics is not limited to the purely academic domain. It has entered the field of technology and industry. This paper will highlight the importance of the integration of knowledge and communication technologies (ICT) into the teaching and learning of mathematics in TeacherTraining College and School level. The methodology of the research is a different type involving an interpretative, conversation, observation and study secondary sources, like books, articles, journals, thesis, university news, expert opinion, and websites, etc. Finally, meaningful suggestions are given.

Keywords: Information and Communication Technologies, ICT Integration, ICT in Mathematics, Mathematical Education, Teacher-Training, Teaching.

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Development of a Mathematics Based Stem Module and Investigation of Its Effectiveness

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In order to be among the economically and socially developing societies, many countries have been making reforms towards a STEM education approach in which disciplines are handled in an integrated manner. Because the STEM education approach is not only a product-oriented approach but also a process-oriented approach (Akarsu et al., 2020), reforms in this area should be supported by qualified curricula. The relevant literatüre reveals that there are a few qualified materials developed according to the STEM education approach (Moore et al., 2014; Guzey et al., 2016). However, existing materials are mostly science-centered, and mathematics was only used as a tool in these studies (For example; Aydın-Günbatar, 2018; Khalil & Osman, 2017).

The fact that mathematics is a communication language for science, engineering and technology (Schmidt & Houang, 2007), it is necessary to design teaching materials that use mathematics effectively in an interdisciplinary education approach. Hence, this current study aims at describing the development of STEM materials that apply mathematics effectively. We decided that ratio and proportion and area measurement subjects from mathematics and matter and heat subject from science due to the difficulty that students, teacher candidates, and teachers experience with these subjects (Arıcan, 2019; Bilir, 2018; Er-Nas & Çepni, 2016). Next, a literature review was conducted on these subjects to develop a mathematics-based STEM module (MB-STEM-M). During this literature review process, the lack of a framework for the evaluation of the MB-STEM-M was also noticed.

To develop MB-STEM-M and measure its effectiveness, we developed a mathemetics-based STEM effectiveness framework (MB-STEM-EF). The research process started with a literature review to determine the key elements that should be included in a qualified module. An initial MB-STEM-EF was developed by adapting these key elements to engineering design process (EDP) (Moore et al., 2013). Later, this framework was updated in the light of expert opinions. Based on MB-STEM-EF, MB-STEM-M was developed, and expert opininons were collected on its compatibility with MB-STEM-EF. An EDP was followed to develop both MB-STEM-EF and MB-STEM-M. The research questions of the study are as follows:

1. What are the opinions of experts regarding the mathematics-based STEM effectiveness framework?
2. What are the opinions of the experts regarding the compatibility of the developed mathematics-based STEM module with the STEM effectiveness framework?

The case study methodology was used in designing this study. Experts' opinions about MB-STEM-EF were analyzed using a content analysis technique in the light of EDP and relevant literature. Likewise, their opinions about MB-STEM-M were coded based on MB-STEM-EF and subjected to the content analysis.

The preliminary results revealed that the experts evaluated MB-STEM-EF as appropriate for developing and evaluating mathematics-based modules. Similarly, experts reported that MB-STEM-M has been created in accordance with the EDP and MB-STEM-EF framework. They emphasized that the developed module can provide strong engineering and technological standards. The general opinion of the experts on MB-STEM-M was that it was a qualified and versatile module. Therefore, this study contributes to the STEM literature by developing a STEM effectiveness framework and a mathematics-based STEM module.

Keywords: Mathematics-based STEM modul, Mathematics-based STEM framework

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