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Examining Non-cognitive Factors Predicting Reading Achievement in Turkey: Evidence from PISA 2018

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Abstract

The purpose of the study was to investigate how student and teacher-related non-cognitive variables were important factors in the reading performances of Turkish students in PISA 2018. The results of the HLM analysis revealed that economic, social, and cultural status (ESCS) as a background variable was considered an effective predictor of student and school reading achievement. The students' meta-cognitive strategies were the most influential variables among their non-cognitive variables. Besides, most of the teacher-related non-cognitive factors had significant relationships with reading achievement even after controlling all student-related and background variables. Teachers' instructional behaviors, such as adaptive instruction and teacher-directed instruction, are much more related to reading performance than other teacher behaviors. The results suggested that fostering soft skills is essential for both students and teachers.

Keywords: Reading Achievement, Meta-cognitive strategies, Adaptive instruction, Teacher-directed instruction, Hierarchical linear models

Introduction

Non-cognitive outcomes are equally important as cognitive outcomes in education. These two fundamental human competencies are influential in the 21st century. Non-cognitive competencies have a vital role in success in school, work, and life (Gabrieli et al., 2015). Certain types of non-cognitive skills play a crucial role in improving cognitive skills, academic achievement, and education systems (Aksu & Güzeller, 2016; Heckman et al., 2006; Gabrieli et al., 2015; Gamazo & Martinez-Abad, 2020; Khine & Areepattamannil, 2016; OECD, 2019a, 2019b). Non-cognitive or soft skills represent personal attributes and skills. Non-cognitive factors, also used as a broader term, include behaviors, attitudes, and strategies. This construct represents several psychosocial dispositions such as beliefs, attitudes, self-efficacy, meta-cognitive strategies, behaviors, emotions, and motivation. These skills have two main categories: intrapersonal (human attributes of how they manage themselves) and interpersonal (how they interact with others) (Gabrieli et al., 2015). Psychological and emotional attributes that influence student learning are easily affected by change from environmental factors, experiences, and social interactions (Lee & Shute, 2010).

Traditionally, the importance of the development of students' cognitive skills, such as academic skills and content knowledge, is focused intensely (Wanzer et al., 2019). For instance, the studies include the effects of psychometric intelligence (Furnham et al., 2006; Hannon, 2016; Malhotra, 2020); the effect of working memory (Bergman Nutley & Söderqvist, 2017; Çalışkanel, 2013; Swanson & Alloway, 2012) on academic performance and learning. However, cognitive factors are not the only factors that influence academic achievement (Cunha & Heckman, 2008; Lee & Shute, 2010). Non-cognitive factors representing students' characteristics such as their behaviors, attitudes, and personalities are also main determinants of achievement (Allen et al., 2009; Fonteyne et al., 2017). Non-cognitive factors consist of several constructs. Background factors, attitudes, interests, coping skills and strategies, thinking style, temperament are potential lists of non-cognitive factors (Messick, 1979). Self-concept, self-efficacy, attitudes, personality, learning process, social and emotional skills are also classified as non-cognitive factors (Lipnevich & Roberts, 2012; Sedlacek, 2010). It shows that the classification of non-cognitive constructs is not all clear (Fonteyne et al., 2017).

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A growing number of studies indicate that non-cognitive variables have been shown to impact on academic achievement (Gutman & Schoon, 2013; Hattie, 2009; Lee & Shute, 2010; Lee & Stankov, 2018; Wanzer et al., 2019). Hattie (2009) synthesized almost 800 studies through meta-analysis. The results showed that engagement, motivation, self-concept, anxiety, and attitude towards mathematics were the strongest non-cognitive predictors of academic achievement. Lee & Shute's (2010) literature review indicated that achievement is not only affected by cognitive factors but that motivational, affective, and contextual factors are also important. The results of the study showed that various variables were related to students' academic achievement at K-12 school levels. They grouped psychological constructs into four major domains. These domains are: (1) student engagement including behavioral, cognitive-motivational, and emotional engagement; (2) learning strategies including cognition, metacognition, and behaviors; and (3) school climate-related social-contextual factors such as teacher interaction, school atmosphere, and (4) social-familial impacts consisting of parents' and peers' motivation, affect, and behaviors. Farrington et al. (2012) also suggested that five general categories of non-cognitive factors (academic behaviors, academic perseverance, academic mindsets, learning strategies, and social skills) are associated with academic performance. In particular, teachers have a crucial role in students' achievement and their attitudes toward school (OECD, 2019a, 2019b; Yıldırım, 2012). According to the expectancy-value model, teachers' behaviors positively affect student motivational beliefs and academic achievement (Wigfield & Eccles, 2000). Teachers' support such as encouraging and helping students with their learning, making them progress, and giving opportunities to express themselves in classroom activities (OECD, 2019a; Klem & Connell, 2004). Besides, teachers' effective instructional practices such as providing clear learning goals, encouraging students to talk about their thinking, and providing feedback to students on their progress are essential for student motivation and learning (Popham, 2000; Tyler, 2000).

International Large-Scale Assessments

International large scale assessments such as Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), or Progress in International Reading Literacy Study (PIRLS) have a significant impact on educational research studies, and also national policies and practices (Gamazo & Martinez-Abad, 2020; Lingard et al., 2013). These assessments allow educational researchers to study deeply the databases that are reported by the OECD. International large-scale assessments have mainly focused on cognitive assessment (Klieme, 2016; Wu, 2010). However, non-cognitive outcomes have been less focused on these assessments (He et al., 2019). These assessments administered to students, teachers and principals in PISA and TIMMS surveys provide to understand the influences of contexts and factors on student learning (Ersan & Rodriguez, 2020; He et al., 2019; Mullis & Martin, 2013). Self-reported likert scale items are administered to measure non-cognitive factors in these large-scale surveys. Lee and Stankov (2018) examined the relationship between non-cognitive variables and academic achievement in TIMMS and PISA. They found that self-efficacy variable in PISA and confidence variable in TIMMS were the strong predictors of student math achievement. Besides, educational aspiration in both PISA and TIMSS was also the best predictor of student math achievement. Moreover, Ma et al. (2021) examined the effects of perceived teacher support and motivational beliefs on student reading performance by using a multilevel mediation model in the Chinese sample of PISA 2018. Their results indicated that teacher support and motivational beliefs are important predictors of student learning. Overall, the results showed that non-cognitive factors have a crucial role in academic achievement. Given the literature, the studies delve deeper into databases to investigate relationships among non-cognitive variables by using different methods that are unreported by the OECD. Investigating the effects of different types of non-cognitive factors is crucial due to their potential positive influences on student academic achievement. Thus, the purpose of the present study was to explore the relationship between non-cognitive factors and reading achievement in the Turkish sample of PISA 2018. It is expected that research findings can help to better understand non-cognitive factors in predicting student achievement in Turkey by using a multi-level model.

Method

This study has a cross-sectional design that examines the relationship between student reading achievement and student-related variables in the PISA 2018 dataset.

The Database and Sample

PISA (International Student Assessment OECD Programme) periodically assesses and monitors 15-year-old students' knowledge and skills at the end of their compulsory education (OECD, 2019a). The PISA assessment design randomly samples 15-year-old students from each school. The survey gathers questionnaire data only

from students. Students participating in PISA not only respond to questions about reading, mathematics, and science but also about themselves, their teachers' teaching qualities and practices, and their schools.

PISA measures students' performances in three main domains: reading literacy, mathematics literacy, and science literacy. Reading literacy was the major domain of assessment in PISA 2018. The student level and school level data for the present study were collected from the PISA 2018 database for Turkey. 6890 students from Turkey have participated in PISA 2018. However, missing values exist in selected factors for the present study. Hence, 6850 15-year-old students from 186 schools were sampled to represent the target population for analysis after exluding missing values.

Measures

The outcome measure for the study was student reading achievement as measured by reading literacy in PISA 2018. The research included some of the non-cognitive variables to address the relationship between reading literacy and non-cognitive factors in the dataset. The variables categorized into major research factors are described in Table 1 (Farrington et al., 2012; Lee & Stankov, 2018). Several students' non-cognitive variables like reading enjoyment, disciplinary climate, and meta-cognitive strategies as provided in Table 1 were included in the study. ESCS refers to family economic, social, and cultural status was used as a student background variable. Teacher related non-cognitive variables representing teacher behavior such as adaptive instruction, teacher support, and teacher feedback were also included in the study.

Table 1. Description of non-cognitive factors in PISA 2018

Factors	Non-cognitive variables and variable labels in the PISA 2018 database
Affect	Enjoyment of reading (JOYREAD)
School Climate	Disciplinary climate (DISCLIMA), Perception of competitiveness at school (PERCOMP), Perception of cooperation at school (PERCOOP)
Personality	Sense of belonging to school (BELONG)
Planned Behavior	Attitude towards school: Learning activities (ATTLNACT)
Learning Strategies	Metacognitive awareness about reading strategies: summarizing (METASUM), understanding and remembering (UNDREM), assessing credibility (METASPAM)
Self-beliefs	Self-efficacy (resilience) (RESILIENCE), Self-concept of reading: perception of competence (SCREADCOMP) and perception of difficulty (SCREADDIFF)
Motivation	Competitiveness (COMPETE), Mastery of Goal orientation (MASTGOAL), Work mastery (WORKMAST), Fear of failure (GFOFAIL)
Teacher Behavior	Adaptive instruction (ADAPTIVITY), Teacher-directed instruction (DIRINS), Teacher support (TEACHSUP), Teacher enthusiasm (TEACHINT), Teacher feedback (PERFEED), Teachers' stimulation of reading engagement (STIMREAD)

Statistical Analyses

First of all, descriptive statistics were used to examine all variables. Since PISA data has a nested structure where students are nested within schools, multilevel analysis was conducted by using hierarchical linear modeling (HLM) (Raudenbush & Bryk, 2002). This approach is suitable for several reasons (Raudenbush & Sampson, 1999): the multi-level design model helps to handle unbalanced large-scale data, includes all information from the data set, estimates all parameters, and measures predictors without error. P-P plots were examined at Level 1 and Level 2 for normality assumptions in PISA 2018 for Turkey dataset. It showed that the assumption was not violated.

Reading literacy as a dependent variable was measured in 10 plausible values estimated with item response theory (IRT): understanding, evaluating, reflecting, and engaging with texts (OECD, 2019a). To estimate reading literacy, each of ten data sets for reading literacy (ten plausible values) as an outcome was measured in the study. The IDB analyzer (OECD 2016a) was used to get syntax for all plausible values and weights. HLM 8 (Raudenbush et al., 2019) was employed for hierarchical linear modeling.

A two-level HLM was conducted in the present study. The analysis consisted of three stages. At the first stage, a one-way analysis of variance model (null model) was conducted to allow partitioning of reading performance into within and between school variances. Intra Class Correlation (ICC) value was calculated for the null model to determine whether HLM analysis was suitable for the data. In Model 1, the variables of students' non-

cognitive factors and student ESCS as background variable at the student level and school average ESCS at the school level were added. Model 2 was extended to include the variables of teacher-related factors at the student level and school-average ESCS at the school level. Ultimately, all student, teacher, and school-related factors were included in the full model.

Results

Descriptive Statistics

According to the original PISA 2018 dataset for Turkey, 6890 students and 189 schools exist in the sample. After cases with missing values were excluded from the dataset, the final sample of the data had 6850 students with 186 schools. Table 2 indicates the descriptive statistics for students, teachers, and school characteristics. PISA 2018 questionnaires with a mean of 0 and a standard deviation of 1 scale index for OECD countries (OECD, 2017). Negative scores show that students responded more negatively than the average student across OECD countries. Turkish students more negatively responded than the average student across countries' characteristics for most of the non-cognitive factors and background variable (ESCS). However, they responded more positively than the OECD average for most of the teacher-related factors.

Table 2. Descriptive statistics at student level and school level variables

Student Level Variables (Level 1) (N=6850)	M	SD	Min	Max
ESCS	-1.71	1.17	-4.75	2.76
Reading enjoyment	0.68	0.97	-2.73	2.65
Motivation to master tasks	0.01	1.09	-2.73	1.81
Fear of failure	0.11	1.00	-1.89	1.89
Mastery Goal Orientation	-0.05	1.12	-2.52	1.85
Competitiveness	0.32	1.21	-2.34	2.00
Self efficacy	0.35	1.14	-3.16	2.36
Self-concept of reading: perception of competence	0.02	0.97	-2.44	1.88
Self-concept of reading: Perception of difficulty	-0.09	0.95	-1.88	2.77
Meta-cognition: summarising	-0.15	0.96	-1.72	1.36
Meta-cognition: understanding remembering	-0.07	0.95	-1.64	1.50
Meta-cognition: assess credibility	-0.24	0.96	-1.41	1.33
Sense of belonging to school	-0.14	1.02	-3.25	2.75
Disciplinary climate	-0.07	0.95	-2.71	2.03
Perception of competitiveness at school	0.34	1.09	-1.98	2.03
Perception of cooperation at school	-0.01	1.15	-2.14	1.67
Attitude towards school: learning activities	-0.11	1.06	-2.53	1.08
Teacher support	0.21	0.93	-2.74	1.34
Teacher feedback	0.02	1.01	-1.63	2.01
Teacher directed instruction	0.22	1.00	-2.94	1.82
Teacher enthusiasm	-0.09	1.08	-2.21	1.82
Adaptive instruction	0.06	0.97	-2.26	2.00
Teachers' stimulation of reading engagement	0.07	1.01	-2.30	2.08
PISA Reading achievement	464.82	84.22	210.67	725.22
School level variables (N= 186)				
Mean SES	-1.19	0.75	-3.55	1.10

HLM Analysis Results

In order to answer the research question, two HLM models were used in the study. The HLM analysis results are provided in Table 3. First, the random effects model (null model) provided the total variance of reading performance between and within schools. Overall, mean score for reading literacy was 459.93 with 4.96 standard error. The Intra Class Correlation (ICC) value represents the proportion of variance in reading performance across schools and was calculated. The ICC value was .61, which indicated that 61% of the variance was explained in overall reading performance among schools in Turkey.

In Model 1, results showed that non-cognitive variables significantly related to reading performance after controlling student ESCS and school ESCS except some of the variables related to school climate (perception of

competitiveness and cooperation at school), and sense of belonging to school. Meta-cognition indices had a much stronger relationship with reading performance than other student non-cognitive variables (assess credibility, $\beta = 11.64$, $p < .05$; summarising, $\beta = 7.14$, $p < .05$). As shown in Model 2, teacher-related variables were found to be significantly related to reading performance except the variable of teacher enthusiasm. Adaptive instruction was the largest predictor ($\beta = 5.35$, $p < .05$) on reading performance with an increase in one unit associated with about 5 points increase in score. Finally, full model including all student and teacher-related factors showed that ESCS, all motivational variables (competitiveness, mastery of goal orientation, work mastery, and fear of failure), self-belief variables, learning strategies (meta-cognition), and affect variable (reading enjoyment) showed a significant relationship with reading performance at the student level. Meta-cognition indices had the strongest predictors of reading achievement (assess credibility, $\beta = 11.29$, $p < .05$; summarising, $\beta = 7.13$, $p < .05$; understanding and remembering, $\beta = 6.04$, $p < .05$), followed by self-concept of reading. Perception of competence was positively related with reading performance ($\beta = 5.96$, $p < .05$) but perception of difficulty was negatively related ($\beta = -6.34$, $p < .05$). In addition, only disciplinary climate had a positive relationship with reading performance. Overall, the fixed effects of student non-cognitive variables were almost the same after controlling all teacher-related and school-related variables. Besides, most of the teacher-related factors were statistically significant in relation to reading performance after controlling student non-cognitive variables and school variables in the full model. The teachers' adaptive instruction ($\beta = 3.87$, $p < .05$) and teachers' directed instruction ($\beta = -3.60$, $p < .05$) had a higher association than the other teacher-related variables on reading performance. When considering the direction of relationship, teacher-directed instruction, teacher feedback, and teacher enthusiasm were negatively related with on average with reading literacy. Mean ESCS as a school level variable also showed a significant relationship with reading literacy.

Table 3. HLM analysis results for reading performance

	Null Model Coefficent (β) (*SE*)	Model 1: Student only	Model 2: Teacher only	Model 3: Full model Coefficent (β) (*SE*)
Intercept, $\gamma 00$	459.93 (4.96)***	466.25 (2.94)***	461.10 (3.54) ***	464.82 (2.90) ***
Student level				
Student background				
ESCS		3.25 (0.71)***	4.65 (0.75)***	3.57 (0.70) ***
Student non-cognitive factors				
Reading Enjoyment		4.04 (0.84)***		4.01 (0.83)***
Motivation to master tasks		-3.00 (0.79)***		-2.98 (0.80)***
Fear of failure		1.74 (0.64)**		1.62 (0.66)*
Mastery of Goal Orientation		-4.57 (0.70)***		-4.39 (0.72)***
Competitiveness		3.73 (0.68)***		3.76 (0.67) ***
Self efficacy		2.29 (0.72)**		2.09 (0.74)**
Self-concept of reading: perception of competence		5.63 (0.81)***		5.96 (0.82)***
Self-concept of reading: Perception of difficulty		-6.24 (0.74)***		-6.34 (0.75)***
Meta-cognition: summarising		7.14 (0.82)***		7.13 (0.79) ***
Meta-cognition: understanding remembering		6.23 (0.77)***		6.04 (0.79) ***
Meta-cognition: assess credibility		11.64 (0.82)***		11.29 (0.79) ***
Sense of belonging to school		0.03 (0.63)		0.16 (0.65)
Disciplinary climate		3.13 (0.81)***		3.27 (0.80) ***
Perception of competitiveness at school		0.05 (0.67)		0.33 (0.68)
Perception of cooperation at school		-0.73 (0.63)		-0.60 (0.62)
Attitude towards school: learning activities		1.45 (0.71)*		1.40 (0.72)
Teacher related factors				
Teacher support			2.87 (0.79)***	2.26 (0.80)**
Teacher feedback			-3.91 (0.79)***	-2.80 (0.83)***
Teacher-directed instruction			-3.76 (0.85)***	-3.60 (0.89)***
Teacher enthusiasm			0.18 (0.79)	-2.23 (0.78)**
Adaptive instruction			5.35 (0.93)***	3.87 (0.94)***
Teachers' stimulation of reading engagement			2.91 (0.92)**	1.59 (1.01)

School level			
School Mean ESCS	49.94 (4.23)***	55.50 (4.98)***	49.33 (4.16)***
Explained variance by the model			
Within-school variability (%)	0.21	0.03	0.22
Between-school variability (%)	0.65	0.49	0.67

p<.05, **p<.01, *** p<.001

The proportion of variances explained by each model is also provided in Table 3. The following formula was used to calculate the proportion of variance at level 1 and level 2 in HLM (Luo & Azen, 2013):

$$R^2 = 1 - \frac{\theta}{\theta_{null}}$$

θ represents the variance component in the level 1 or level 2, and θ null represents the model without predictors. In Model 1, 21% of the student level variation was explained by the inclusion of student non-cognitive variables, whereas 65% of the school level variance was explained by the inclusion of school mean ESCS. In Model 2, student-level variables related to teacher behaviors explained only 3% of the student-level reading literacy score variance, and school-level variance (school mean ESCS) explained 49% of the school-level reading literacy score variance. Lastly, all of the variables at both levels were included in Model 3. The amount of variance in mean reading literacy for Turkey within schools and across schools was 22% and 67%, respectively. The explained variance has been increased when all student, teacher-related, and school-related variables are included as a full model when compared to the explained variances in Model 1 and Model 2.

Discussion

Through HLM analysis, this study was aimed to investigate to identify the most important non-cognitive factors on reading performances of Turkish students in PISA 2018. The study proposed an explanatory model to predict some of the non-cognitive of student-related and teacher-related factors on reading performance. ESCS as a background variable was considered an effective predictor of student and school reading achievement. The finding, in line with previous studies (Dinçer & Uysal, 2010; Ersan & Rodriguez, 2020; Smiths & Gündüz Hoşgör, 2006; Tabak & Çalık, 2020), showed that ESCS was a prominent factor explaining student achievement. The results revealed that most of the non-cognitive measures in PISA 2018 have a significant relationship with student reading performance. Meta-cognitive strategies in special meta-cognition: assessing credibility were the best predictors of reading performance at student level in PISA. The finding was consistent with previous studies regarding PISA 2018 using different groups and methods (Depren & Depren, 2021; Gamazo & Martinez-Abad, 2020). Depren & Depren (2021) focused on the high levels of students in PISA 2018 for Turkey and China by using the activity region finder algorithm method. Meta-cognition competencies specifically meta-cognition: assess credibility was the only factor that maximize the student achievement among other variables both Turkey and China. The findings generally showed that students in Turkey were well aware of meta-cognitive strategies and able to use them efficiently. The students who use higher level of these strategies are more successful in reading literacy. Several studies also showed that students' use of meta-cognitive learning strategies contributes to developing their reading literacy (Carrell et al., 1998; Şen, 2009; Qi, 2021). Thus, it is important to develop students' meta-cognitive capabilities as twenty-first century skills. In the group of self-beliefs construct, variables of self-concept, including perception of ability and perception of difficulty, were the best predictors of individual-level student achievement in reading literacy. Academic self-concept has also been highlighted by previous studies (Chapman et al., 2000; Ma et al., 2021). The other influential non-cognitive factors in the model were reading enjoyment as an affect variable, mastery of goal orientation among motivational variables, and disciplinary climate in the school climate construct. Academic emotions in different subjects, like reading enjoyment, play an important role in students' cognitive processes, their decisions, motivation, and achievement (Pekrun, 2006; Pekrun et al., 2017; Goetz et al., 2008). Student achievement is also associated with mastery-approach goals. Students adopting mastery goals are more likely to gain an increase in understanding, development, and success even when they face difficulties. (Ames & Archer, 1988). The present study showed a negative relationship between students' goal-oriented attitudes and their reading performance. The OECD reported that 21 countries, including Turkey, had more than 5% of students who had an immigrant background. PISA 2018 results showed that immigrant students in many countries tend to show low performance and have surprisingly more goal-oriented attitudes than non-immigrant students (OECD, 2019c, p.201). Reports of immigrant students who had more goal-oriented attitudes than non-immigrant students may explain the negative relationship between mastery goal orientation and reading

performance in the study. Lastly, the disciplinary climate in a school was a significant predictor of reading performance. Students who reported being in a positive school environment had higher performance in reading literacy than students in a negative school environment.

The results showed that most of the teacher-related factors had significant factors even after all student-related factors and background variables were taken into account. Regarding teacher behaviors, teachers' instructional behaviors, such as adaptive instruction, and teacher-directed instruction have much more influence on reading performance than the other teacher-related factors. The results showed that students in Turkey mostly benefit from the teachers' instructional approach. Students who felt supported by their teachers showed higher performance in reading literacy. Several studies also reported that teachers' support was associated with students' higher academic performance (Ma et al., 2021; Ricard & Pelletier, 2016; Yıldırım, 2012; Yıldırım & Yıldırım, 2019). Adaptation of instruction showed a significant relationship with reading literacy. Teachers adjust their instructions in response to student needs. Similarly, research studies show that teachers' ability to adapt instruction is likely to increase student achievement (Gambrell et al., 2011; Kalkan et al., 2020). While teacher support and teacher adaptive instruction are positively associated with reading performance, other teacher-related behaviors, such as teacher-directed instruction, teacher feedback, and teacher enthusiasm, were negatively associated with reading performance. The research studies reported that teacher instructional practices (e.g. teacher-directed instruction, teacher feedback) (Boston, 2002; Connor et al., 2004) had a strong impact on low-achieved students. The present study also revealed that low-achieved students had higher scores in reading when their teachers were more enthusiastic in the classrooms. These negative relationships might be explained by the nature of the PISA test design (OECD, 2016 b, p. 68). Teachers' use of different instructional strategies and their different behaviors can help different student groups (i.e., advantaged or disadvantaged students, or advantaged-disadvantaged schools).

Conclusion

The present study showed that student-related and teacher-related non-cognitive variables play crucial roles in students' reading achievement. Most of the student non-cognitive variables were significantly associated with reading performance, especially meta-cognitive strategies, which were the strongest. Teacher-related non-cognitive variables are also significantly related to reading achievement. Teachers' instructional behaviors were the most influential predictors in explaining reading achievement. Overall, fostering these soft skills for both students and teachers in schools is important to increasing student achievement.

Limitations

In the present study, the relationship between some of the non-cognitive factors and reading achievement was investigated with the HLM model by using cross-sectional data. In further research, more student-related, teacher-related, and school-related variables should be included in the multi-level model. In order to understand more about the relationship among non-cognitive variables, multilevel path analysis should be done in further studies. In addition, the present study relied on student self-reported data in the student questionnaire. Despite its some limitations, the results of this study contributed to understanding various student and teacher-related non-cognitive variables and their relationship with student reading achievement. In general, the results suggest that fostering soft skills is important not only for students but also for teachers. Conducting experimental or longitudinal studies to investigate any causal effects about the effectiveness of non-cognitive factors would be important to enlighten in the further studies. Examining and comparing non-cognitive factors across different cultures would also be useful.

Conflicts of Interest

There is no conflict of interest for individuals or institutions in this research.

Ethical Approval

Ethical permission (2022/018) was obtained from Sinop University institution for this research.

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Coding in Preschool Science and Mathematics Teaching: Analysis of Scratch Projects of Undergraduate Students

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Coding in Preschool Science and Mathematics Teaching: Analysis of Scratch Projects of Undergraduate Students

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Abstract

This paper analyzed Scratch projects developed by undergraduate students. The sample consisted of 22 child development students (18 women and four men) in the 2018-2019 academic year. The study adopted an action research design within the scope of a course titled "Teaching Science and Mathematics in Preschool Education." The research was conducted within 14 weeks. In the first four weeks, we provided participants with training on why and how to use Scratch in science and mathematics teaching. In the following ten weeks, participants designed Scratch projects every week based on age groups, topics, and learning outcomes of their choice. Participants evaluated their projects themselves and also received feedback from peers and academics. Each participant designed ten Scratch projects (five for math and five for science). The data consisted of 220 Scratch projects and design logs. The study included a thematic content analysis. In the first weeks, participants knew little about the content of Scratch and used one or two characters and mostly control and look blocks. In the following weeks, they learned more about Scratch and used different blocks.

Keywords: Scratch, Science education, Mathematics education, Preschool education, Coding

Introduction

In recent years, visual programming languages (Alice, code.org, Scratch, etc.) have made coding popular in education. Such programming languages teach young children how to use codes without having to learn complicated code structures (Resnick et al., 2009). They help children create their own stories, animations, interactive games, and simulations to learn math and science skills and topics (Taylor, Harlow & Forret, 2010). Scratch is the most popular block-based software to teach beginners how to code (Zhang & Nouri, 2019). Apps like Scratch are defined as visual programming tools because they are based on the "drag and drop" feature, by which the user can simply choose visual elements and drop them wherever she wants. In other words, they offer a simple interface that allows children to design and produce without making coding errors. Children who receive programming education at an early age are more likely to develop metacognitive skills (divergent thinking, creativity, and channelization) (Atmatzidou & Demetriadis, 2016). Therefore, schools should provide children with coding education from an early age (Calder, 2010). Coding is a 21st-century skill and a part of logical reasoning (European Commission, 2014a). Many European countries have included coding in their curricula to help students develop logical thinking and problem-solving skills. Some countries have integrated coding into their curricula to stimulate employment (Balanskat & Engelhardt, 2015). Scratch teaches young learners how to code and helps them develop higher-order thinking skills (Zhang, Yang, Luan, Yang, & Chua, 2014). It also provides students with the opportunity to learn math and science concepts.

Educational institutions, researchers, teachers, and government agencies such as the NSF have worked to develop sustainable curricula that encourage students to learn programming at an early age. However, some obstacles are encountered in practice. For example, insufficient professional development services for teachers (Buss & Gamboa, 2017); insufficient evidence of the impact of practices using innovative learning environments (for example, Code.org or Scratch) (Kalelioğlu & Gülbahar, 2014; Moreno-León, Robles & Román-González, 2016) It has been suggested that many schools today adopt block-based programming environments such as Scratch to solve their problems. Even though most teachers provided the use of Scratch in

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their classrooms, they were insufficient to evaluate the quality of the projects created by the students and to give feedback to them according to the results (Kwon, Lee & Chung, 2018). Teachers want to answer the question: how to evaluate the quality of students' scratch programs? For example, Dr. Scratch automatically evaluates the scratch program (Moreno-León, Robles, &Román-González, 2015). As another example, students' programming competencies and strategies in Scratch programs include 1-computational concepts (data representation, iteration with certain loops, etc.), 2-computational designs (task sequences, parsing problems, etc.), and 3-it can be evaluated as their computing performance (determination of targets, usability, etc.) (Chao, 2016). Quantitative indicators of scratch programs can show the size and complexity of a program (Aivaloglou & Hermans, 2016).

Literature Review

Using Scratch in Science and Mathematics Education

It is important that students, especially those in the pre-school period, can achieve meaningful and permanent learning in science and mathematics and develop positive attitudes. With the use of Scratch, abstract concepts such as variables in algebra can be learned in mathematics education (Fesakis et al., 2013). In addition to easier learning of abstract concepts containing variables, it also improves students' high-level thinking skills (Monroy Hernandez & Resnick, 2008). Considering that many subjects in science are abstract (e.g., atoms, photosynthesis, global warming, etc.), modeling may be required to make it easier for students to visualize these subjects. Modeling helps us understand its real-world effectiveness by simplifying some of the features of the phenomenon (Weintrop et al. 2016). Students can design and create their own models (Weintrop et al. 2016). Models are important in promoting inquiry, conceptual change, and representative literacy (Brennan & Resnick 2012). The NGSS emphasizes the importance of students creating models (Weintrop et al., 2016). Scratch is also an environment that can be used effectively in model creation.

Scratch

Scratch, which has the most common use as block-based programming, also offers a rich interactive programming opportunity in terms of media. Scratch is a free-to-use graphical programming language (http://scratch.mit.edu/) designed to facilitate and improve technological fluency (Resnick & Silverman, 2005). Scratch is developmentally based on the ideas of Seymour Papert (Papert, 1980) and was developed at the Massachusetts Institute of Technology's (MIT) Media Lab. Papert's ideas support Scratch design with "repairability", as one of its main goals is to assemble, disassemble, and reassemble the building blocks of coding to build what child programmers want (Resnick, 2007). With Scratch, users can solve and reassemble blocks as they logically develop the moves and effects they want. It therefore allows for creative and accessible programming. It has a program interface with three different areas. It is the left part where the programming blocks are located. Each of these blocks has its own function and can be dragged into the script and put together to create programs. With the "drag-and-drop" function in Scratch, the need to remember codes or understand syntax is eliminated (Otrel-Cass, Forret, & Taylor, 2009). Writing a syntactically incorrect script is possible in programming languages. Scripts do not fit together unless they are written from scratch. Therefore, it makes learning and creating programs easier and allows the child programmer to spend more time on the logic and creative elements of the programs (Otrel-Cass, et al., 2009). Using different shapes and combining commands with parts prevents syntactic errors by restricting the structures in the program (Bau, Gray, Kelleher, Sheldon, & Turbak, 2017). The middle part, where the script or program is located, is the area where the programming blocks are combined. In the upper right corner, there is the “scene” where the graphic elements are placed.

Scrach allows users to create their own interactive stories, animations, games, or images. While working individually and collaboratively on interactive stories, games, and animations, 21st century skills such as critical thinking, creativity, communication, and cooperation can be learned, as well as mathematical and computational concepts (Maloney et al., 2010; Resnick et al., 2009). Users can share their created projects online. It can be used for teaching and learning purposes in many subjects, such as mathematics, science, music, and art. Although simple and easy to use, the projects put forward are complex and comprehensive and offer a fun learning environment. While it is enjoyable for children to explore and create creative products with programming, it also contributes to their understanding of embedded programming and mathematical concepts such as location or orientation. Creative problem solving, facilitating logical reasoning, and collaboration are encouraged with Scrach (Peppler & Kafai, 2006). It makes programming accessible and engaging for everyone on Scratch (Resnick et al., 2009). It is easy for those with limited or no programming background to start

learning programming and can build more complex programs over time (Sáez-López, Román-González, & Vázquez-Cano, 2016; Su, Yang, Hwang, Huang & Tern, 2014).

Scratch was developed by the Massachusetts Institute of Technology (MIT) to make programming easier. It allows users to create animations, games, stories, and interactive projects and share them online. It runs either online or offline. Its interface consists of five sections: (1) a stage where a Scratch project is physically run; (2) blocks; (3) a script area where blocks are placed; (4) an area to choose a backdrop and sprite, and (5) "go" and "stop" buttons. You can choose different backdrops and program their motion. Each object on the stage is a sprite. You can attach sounds and music to a sprite. Codes are in the form of blocks. You can combine codes to program. For example, we use motion blocks to make our sprite walk or look at blocks to change its color or make it talk.

Evaluation of Scratch

There are different methods and approaches in the evaluation of projects created by students. Three-stage evaluation for visual programming (Wilson, Hainey, & Connolly, 2012); it can be expressed as 1-programming concepts (variables, conditions, etc.), 2-code organization (naming variables, etc.), and 3- interface and usability (authenticity, etc.). In another study, Tseng and Weng (2009) stated that student projects can be done in three ways. These are: 1-Logic (program scenario), 2-Code (program flow, scene, etc.) and 3-resources (sound, graphics, etc.). With the help of a system, automatic evaluation can be carried out using these criteria.

Automatic Assessments

It is a system in which programming tasks are evaluated automatically, does not require any special infrastructure, gives detailed feedback, and can get points in a short time for large groups (Sant, 2009). As an example, "Test My Code (TCM), REACT, and Dr. Scratch" can be given as an example. It has been stated that TCM is useful for use at universities (Vihavainen, Vikberg, Luukkainen, & Pärtel, 2013). REACT was developed by Koh et al. (2014) to assess teachers' computational thinking skills. "Dr. Scratch" (http://www.drscratch.org), which is open to everyone and does not charge any fee for its use, is another automated assessment tool. Moreno-Leon et al. (2015) introduced "Dr. Scratch", a web application that analyzes Scratch programs. Dr. Scratch evaluated computational thinking according to seven criteria: 1-abstraction and problem decomposition; 2-logical thinking; 3-synchronization; 4-parallelism; 5-algorithmic concepts of flow control; 6-user interaction; and 7-data representation. When users present their Scratch programs, Dr. Scratch displays the numeric scores of the criteria (from zero to three), as well as the overall mastery level in terms of basic, development, and mastery. Both students and instructors, Dr. Using Scratch, he can easily evaluate Scratch programs and get instant feedback.

Other Evaluations

In the evaluation of the projects prepared by the students, rating criteria lists, tests, self-evaluation, observation notes, etc. can be used. Another assessment tool is the questions in the Bilge Kunduz activity. It is an international event created to teach students computational thinking. In the activity, students are given 45 minutes to complete 18 questions of varying difficulty. For example, 6 points are given for 6 questions at an easy level, 9 points for 6 questions at a medium level, and 12 points for 6 questions at a hard level. For each wrong question, one third of the correct score of that question is taken and subtracted from the total score according to the difficulty level of that question.

Significance of the Research

The importance of this study can be discussed under four headings when the studies in the literature are examined. First, it allowed preschoolers to create their own science and math Scratch projects for ten weeks based on topics and learning outcomes of their choice. To our knowledge, this is the first study to address Scratch projects within the scope of both science and math. Most research focuses only on one field or does not address any specific field at all. Researchers concentrate on math (Lewis & Shah, 2012); English (Moreno-León & Robles, 2015); information and communication technologies (Yildiz, Cobanoglu & Kisla, 2020); science (Adler & Kim, 2018; Tan, Samsudin, Ismail & Ahmad, 2020); and science concepts (Moreno-León, Román-González, Harteveld & Robles, 2017). The second strength of this study was its scope. Studies examine different components of Scratch education, such as academic performance (Korkmaz, 2018; Tan, Samsudin,

Ismail & Ahmad, 2020); computational thinking (Oluk & Korkmaz, 2016; Kwon, Lee & Chung, 2018); pre-programming period (e.g., Java) (Malan & Leitner, 2007; Maloney et al., 2008); and analysis of Scratch projects (Kwon, Lee, & Chung, 2018; Moreno-León et al., 2017; Oluk & Korkmaz, 2016). This study analyzed 220 original Scratch projects. Most researchers analyze Scratch projects that have already been created and archived. The third strength of this study was the way Scratch projects were analyzed. We investigated what types of blocks participants preferred to use and how often they used them, depending on the weeks. Most studies focus on projects created on the Dr. Scratch software program (Adler & Kim, 2018; Altanis & Retalis, 2019; Kwon, Lee & Chung, 2018; Moreno-León et al., 2017; Oluk & Korkmaz, 2016). For example, Moreno-León et al. (2017) compared Scratch projects evaluated by Dr. Scratch (automatically) and experts (manually). Dr. Scratch evaluates the level of development of various aspects of computational thinking. Fifty-three projects created by students were analyzed by both Dr. Scratch and experts. The results show strong relationships between automatic and manual evaluations. The fourth strength of this study was that it focused on the preschool period. There are a handful of studies addressing Scratch use among preschool teachers or preservice preschool teachers. Researchers generally focus on middle school students (Meerbaum-Salant, Armoni & Ben-Ari, 2013; Moreno-León & Robles, 2015; Oluk & Korkmaz, 2016), teachers (Van Zyl, Mentz & Havenga, 2016; Yildiz, Çobanoğlu & Kişla, 2020), and preservice teachers (Altanis & Retalis, 2019; Kwon, Lee & Chung, 2018; Tijani, Callaghan & de Villers, 2020). For example, Moreno-León and Robles (2015) recruited two fourth graders and two fifth graders to conduct an experimental study. The experimental group used Scratch to perform some programming activities on vocabulary and grammar, while the control group adopted a traditional method to address the same topics. The experimental group outperformed the control group. The results showed that coding could be used not only to teach students English but also to help them develop other skills.

Technology has been integrated into the educational process. Therefore, teachers should be able to use their own content to determine students' prior knowledge, to teach new topics, and to evaluate performance. For example, a teacher is expected to create her own content to teach an abstract and hard-to-understand topic, such as the depletion of the ozone layer. She should use Windows Movie Maker to create a video or Scratch to create an animation if she has no access to ready-made content (animation, video, etc.) or if the content she has is not suitable for the learning outcomes she intends to implement. She should be able to develop content based on a predetermined pedagogical approach and have the knowledge to encourage students to develop their own content. Preschool teachers and preservice teachers play a key role in helping young learners develop those skills.

The Aim of the Study

The main purpose of the study is to analyze the code usage frequency and content of Scratch projects prepared by students in science and mathematics subjects. Evaluation of Scratch projects will contribute to students' gaining a perspective of revealing the parts they have difficulty in and designing learning activities in an original way in science and mathematics education. This study analyzed science and math Scratch projects created by undergraduates. The research questions are as follows:

- What is the frequency of use of blocks in Scratch projects on science and mathematics subjects created by students?
    - What are the science and math subjects in Scratch projects created by students? What is the frequency of use of "topics"?
    - What is the frequency of use of "number of characters" in Scratch projects on science and mathematics subjects created by students?
    - What is the frequency of use of "movement blocks" in Scratch projects on science and mathematics subjects created by students?
    - What is the frequency of use of the "view block" in Scratch projects on science and math topics created by students?
    - What is the frequency of use of "control block" in Scratch projects on science and mathematics subjects created by students?
    - What is the frequency of use of "other blocks" in Scratch projects on science and mathematics subjects created by students?
    - What is the frequency of use of "total blocks" in Scratch projects on science and mathematics subjects created by students?

Method

This paper analyzed preschool science and math Scratch projects created by undergraduates. The study adopted an action research design. Action research aims to examine people's problems, especially those that concern society, with conciliatory, democratic, participatory strategies (Berg, 2001). Action research in the field of education, on the other hand, is a systematic process aimed at solving and improving the problems experienced (Tomal, 2010). Action research takes place differently in the literature (Berg, 2001; Bogdan & Biklen, 2007; Hendricks, 2006; Mills, 2003; O'Brien, 2001). Berg (2001) classified three types (technical, practical, and liberating); Mills (2003) classified two types (critical and applied); Bogdan and Biklen (2007) classified two types (political and participatory); and Hendricks (2006) classified four types (collaborative, critical, in-class, and participatory). This type involves a social and collaborative process. Action research tries to solve the problems experienced in practice.

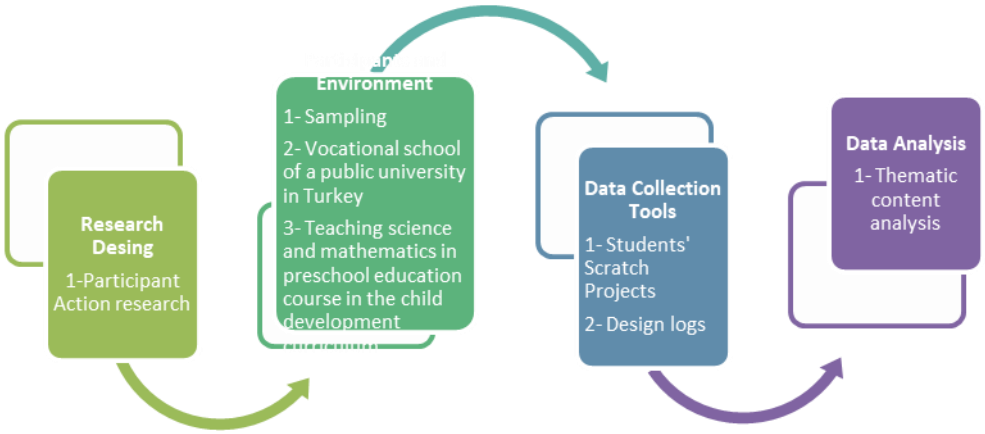


Figure 1. Research Process

Study Group

The sample consisted of 22 fourth-year students (18 women and four men) from the department of child development of a public university in the 2018-2019 academic year. None of the participants had used Scratch before. Most participants had no Internet access or a computer. It was determined that 12 of the students (10 girls and 2 boys) did not have a personal computer and did not have access to the internet. However, it was determined that 10 of the students (8 women and 2 men) had personal computers and only 6 of the women had access to the internet.

Research Process

This study was conducted within the scope of the "Preschool Science and Mathematics Teaching" course offered in the fourth term of the child development program. In the first four weeks, we provided participants with training on how to use Scratch. In training, we held discussions on the purpose and significance of Scratch and showed participants how to use the blocks (motion, sound, looks, etc.), add a new sprite, stage, and sound to a project, move the sprite, change the motion of the sprite based on a condition, and change the looks of the sprite based on a condition. In the following ten weeks, each participant created five science and five math Scratch projects about the preschool topics and learning outcomes of their choosing. Participants drew rough sketches describing the topics, learning outcomes/indicators, age groups, and features (sprites, sounds, etc.) they intended to address in their Scratch projects. They presented their drafts in front of the class, discussed their projects, and received feedback from their peers and teachers. They revised their draft projects based on feedback and moved onto their actual Scratch projects. One week later, they presented their Scratch projects in front of the class and received feedback from their peers and teachers. Table 1 shows the process.

Table 1. Research process

WEEKS	Learning Outcomes
1	Talking to participants about the purpose and importance of Scratch Introducing the Scratch interface and its features - Let's get to know the Scratch interface *Menu, stage, file, edit, stage ve backdrops, sprites, costumes, code, sounds*
2	Introducing the Scratch interface and its features Block Palette *Learning the functions of motion blocks* *Learning the functions of looks blocks* *Learning the functions of sound blocks* *Learning the functions of pen blocks* *Learning the functions of blocks in control block*
3	- Introducing the Scratch interface and its features. Block Palette *-Learning the functions of sensing blocks* *-Learning the functions of variable blocks* *-Learning the functions of operator blocks* -Showing participants the steps of a Scratch Project
4	- Let's explore the blocks *Participants created projects with ten blocks each in 15-20 minutes and then discussed them in class.*
5	-Creating Scratch I projects about preschool science topics -Creating design logs -Evaluating the Scratch projects and giving feedback
6	-Creating Scratch II projects about preschool math topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
7	-Creating Scratch III projects about preschool science topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
8	-Creating Scratch IV projects about preschool math topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
9	-Creating Scratch V projects about preschool science topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
10	-Creating Scratch VI projects about preschool math topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
11	-Creating Scratch VII projects about preschool science topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
12	-Creating Scratch VIII projects about preschool math topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
13	-Creating Scratch IX projects about preschool science topics -Creating design logs. -Evaluating the Scratch projects and giving feedback
14	-Creating Scratch X projects about preschool math topics -Creating design logs. -Evaluating the Scratch projects and giving feedback

Tools for Data Collection

Another data collection tool used in studies is student studies. Student studies can be used as a data source (Johnson, 2014). Student studies are data showing the progress and development of students in the process (Hubbard & Power, 1993, as cited in Cavkaytar, 2009). Data was collected from participants' design logs and Scratch projects. Scratch is a project of the Lifelong Kindergarten (2003) group at the Massachusetts Institute of Technology (MIT) Media Lab. It provides a visual programming environment. It has many language options and appeals to a wide range of users (Çatlak, Tekdal & Baz, 2015). It allows the user to create projects by dragging and dropping without having to write down any codes. The code blocks can go on top of each other or be arranged side by side (Demirer & Sak, 2016). Creating design logs: *Please write down your thoughts and project processes as well as your sources of inspiration throughout your experience. Please write down your questions and their answers before sketching out your designs.* A rich digital programming tool, Scratch is supported by graphics, audio,

and video. Thanks to the blocks in Scratch, they can be kept separate or combined to create the desired movement and interaction. Various concepts (geometric and measurement) are used with measurements such as coordinates, angles, and length that can be used to scratch online or offline. In this study, students created their projects using an offline program (Scratch 1.4).

Data Analysis

Thematic content analysis was carried out in the study. In the study, the main themes were determined and coding criteria were created. For the scratch projects created by the students in the study; 7 themes were created: subject, number of characters, appearance, movement, control, other blocks, and total number of blocks. The evaluation of scratch projects for the determined themes is given below (table 2). Validity, reliability, and coder reliability were assessed using the agreement percentage proposed by Miles and Huberman (1994). Coding was done by the researcher and an independent researcher who is an expert in the field. A consensus of 89% was calculated among the coders.

Table 2. An example of an analysis of a scrtach project in the study

Theme	Subject	Number of Characters	Movement	View	Control	Other Block	Total Number of Blocks
Code	Science subject (Buoyancy)	"Number of characters" used in the science subject (Buoyancy)	"going to x-y position" in the science subject (buoyancy)	"tell (..)" in the science subject (buoyancy)	When "clicking" in the science subject (buoyancy)	In the science subject (buoyancy) "recording… until you turn it off"	In the science subject (buoyancy) "total block usage count"

Results

This section addressed the results and presented them in tables.

Participants preferred to focus on different science and math topics. They had a wider range of selections regarding science topics than math topics (Table 3). They created Scratch projects about buoyancy (N=11), density (N=9), formation of rain (N=8), and mixtures (N=7). Some participants focused on germination (N=6), expansion (N=6), sense organs (N=6), and the importance of water for flowers (N=6). Table 3 shows the topics participants integrated into their Scratch projects.

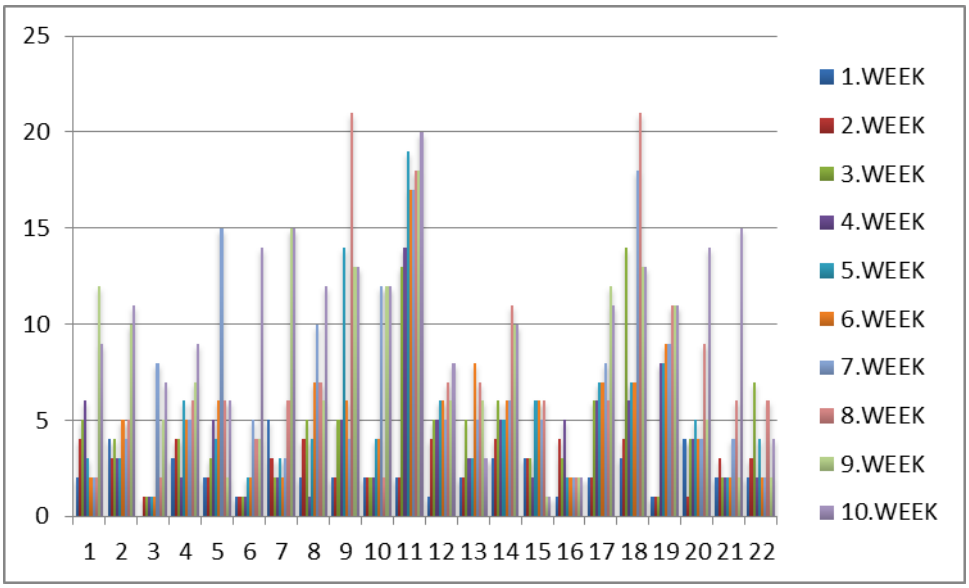
Table 3. Scratch topics

FIELD	TOPICS	N
SCIENCE	Seasons	1
	States of matter	2
	Buoyancy	11
	Refraction	1
	Gases	4
	Mixtures	7
	Germination	6
	What kind of materials does a magnet attract?	2
	Pressure	1
	Let's Get to Know the Animals	2
	Harmful Foods	1
	Formation of rain	8
	Expansion (air expands when heated - non-exploding balloon)	6
	Density	9
	Growing taller	1
	Importance of water for flowers	6
	Photosynthesis	1
	Taste buds on the tongue	2
	Combustion	3
	Metamorphosis of a butterfly	6
	Dissolution	2
	Sense organs	6
	Germs	5
	Growth of a fish	1

	Growth of a frog	1
	Volcanic eruptions	3
	Day-night formation	2
	Whirlwind	1
	Sound	1
	Growth of a bee	1
	Recycle	3
	Benefits of the Sun	1
	Harms of sugar	1
	Dental health	1
	Smell	1
MATH	Long-Short	2
	Matching	18
	Pattern	6
	Geometric shapes	15
	Full-Half	6
	Numbers	26
	Addition and subtraction	13
	Big-Small	13
	Heavy-Light	1
	Classification	1
	Counting	6
	Thin-Thick	1
	Under-Over	1
	Ranking	1

Participants created Scratch projects about 14 math topics. They mainly focused on numbers (N=26), matching (N=18), geometric shapes (N=15), addition-subtraction (N=13), and large-small (N=13). They also created Scratch projects about patterns (N=6), whole-half (N=6), and counting (N=6). Table 3 shows the science and math topics about which participants created Scratch projects.

Graph 1 shows the distribution of characters participants used in their Scratch projects. It was revealed that students were better in mathematics (at 2nd, 4th, 6th, 8th, and 10th weeks) than in science (1st, 3rd, 5th, 7th, and 9th weeks). In the following weeks, it will be seen that the number of characters used is better in mathematics subjects. The number of characters varied across weeks and participants. Some participants used more and more characters as the weeks passed, while others did not show linear progress. For example, participant number 1 used one or two characters in the first week but used more than ten characters in the tenth week. On the other hand, participant number 11 used a sporadic number of characters throughout the weeks.

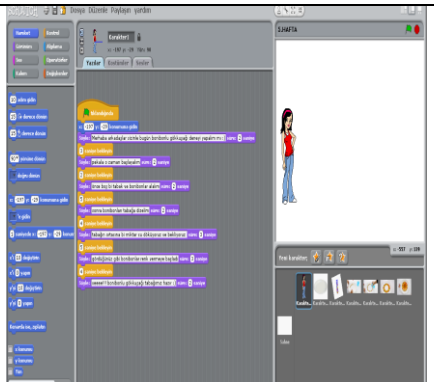


Graph 1. Number of Characters in Scratch Projects

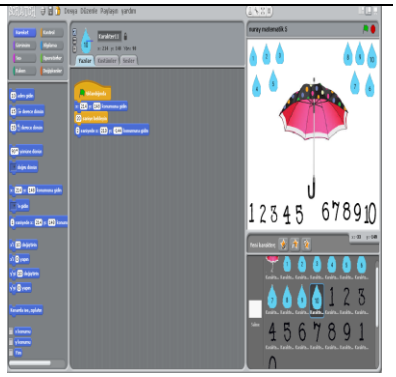
Participants used the same number of characters in some weeks. Some participants used the same number of characters, especially towards the end of the competition. For example, participant number 16 used more

characters in the first weeks but used the same number of characters towards the last weeks. On the other hand, Participant No 5 used the same number of characters in the first weeks, used more characters towards the end of the last weeks, and used fewer characters in the last weeks (Graph 1). You can see below the Scratch projects created by one of the participants: Number 18 in the second, fifth, and eighth weeks.

2.WEEK

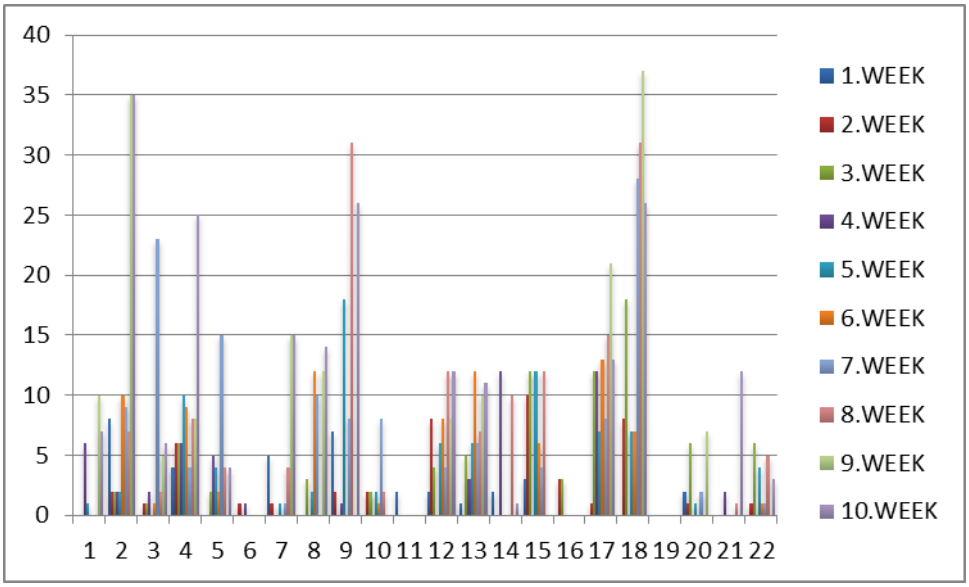


5.WEEK



8.WEEK

The findings obtained from the study showed that there was an improvement in the frequency of use of the motion block in the field of mathematics (at the 2nd, 4th, 6th, 8th, and 10th weeks). There is a development in the frequency and content of motion block use (at 1st, 3rd, 5th, 7th, and 9th weeks) in science subjects. Participants did not use motion blocks very much. Some participants used motion blocks more often as the weeks passed, but some used very few motion blocks in some weeks. They mostly used the following motion blocks: "glide ( ) secs to x: ( ) y: ( )," "move ( ) steps," "turn right (15) degrees," "turn left (15) degrees," "go to x: ( ) y: ( )," "change y by ( )," "if on edge, bounce," "direction," "repeat ( ) times," turn (90) degrees," and "points towards ( )." For example, participants number 9 and 18 used motion blocks much more towards the end of the training.

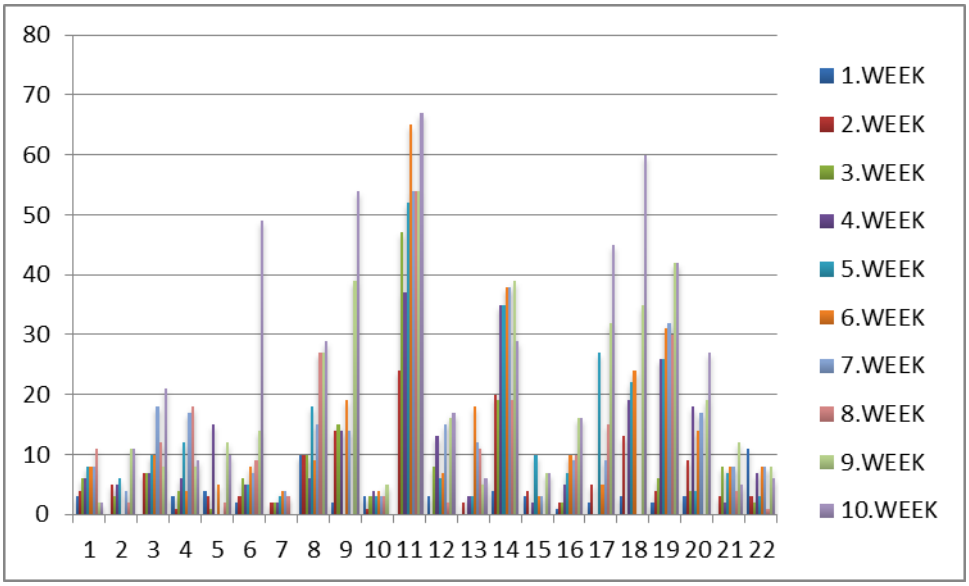


Graph 2. Frequency of use of motion blocks

Some participants never used motion blocks or used them very rarely in some weeks. For example, participant number 19 never used motion blocks, while participant number 21 used them only every two weeks (Graph 2). On the other hand, some participants used motion blocks very often. For example, participant number 18 used them very often in the first and last weeks. What is more, she has used them more in the last few weeks. You can see below the Scratch projects created by one of the participants: Number 2 in the second, seventh, and tenth weeks.

2.WEEK	7.WEEK	10.WEEK

Participants used the look blocks very often. They used them more and more in the last few weeks. When the findings obtained from the study are examined, it is seen that the frequency and content of the use of appearance blocks in the field of mathematics (at the 2nd, 4th, 6th, 8th, and 10th weeks) are enriched by weeks. In addition, in science subjects (at the 1st, 3rd, 5th, 7th, and 9th weeks), an increase is observed in the frequency of use of blocks by students. It is seen that the use of block content in mathematics and science subjects is similar. For example, Participant number 11 used the look blocks more often as the weeks passed and used them the most in the last week. They mostly used the following look blocks: *"say ( )," "add," "think ( ) for ( ) seconds," "show," "hide," "switch costume to ( )," "think (hmm)," "next characters," "change (color) effect by (25),"* and *"think ( )."*

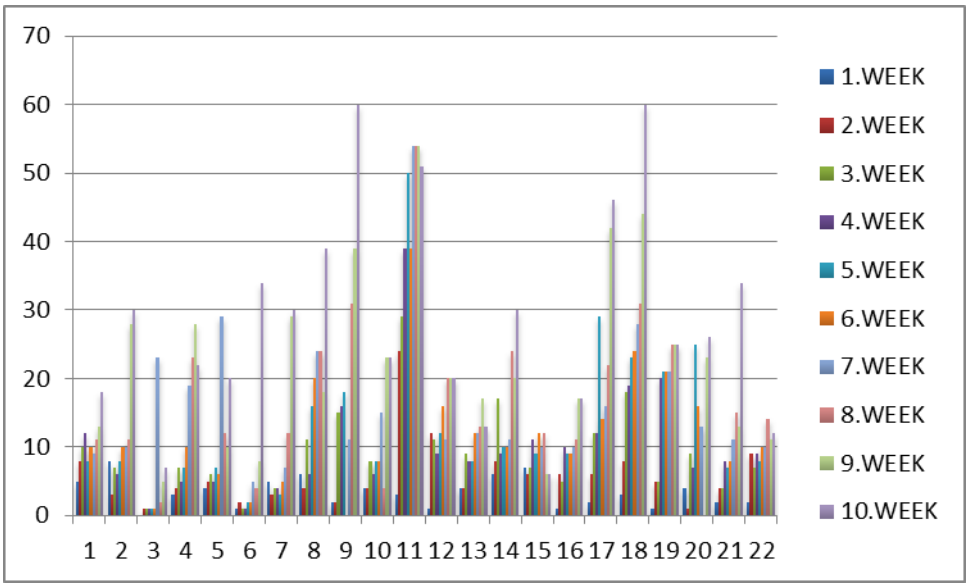


Graph 3. Frequency of use of the view blocks

Some participants made moderate levels of progress, while others made significant progress throughout the weeks. For example, participant numbers 1 made moderate progress, while participant numbers 7 made very little progress. Participants mostly used the look blocks of *"say ( ), "show,"* and *"hide."* You can see below the Scratch projects created by one of the participants: Number 11 in the first, fourth, and seventh weeks.

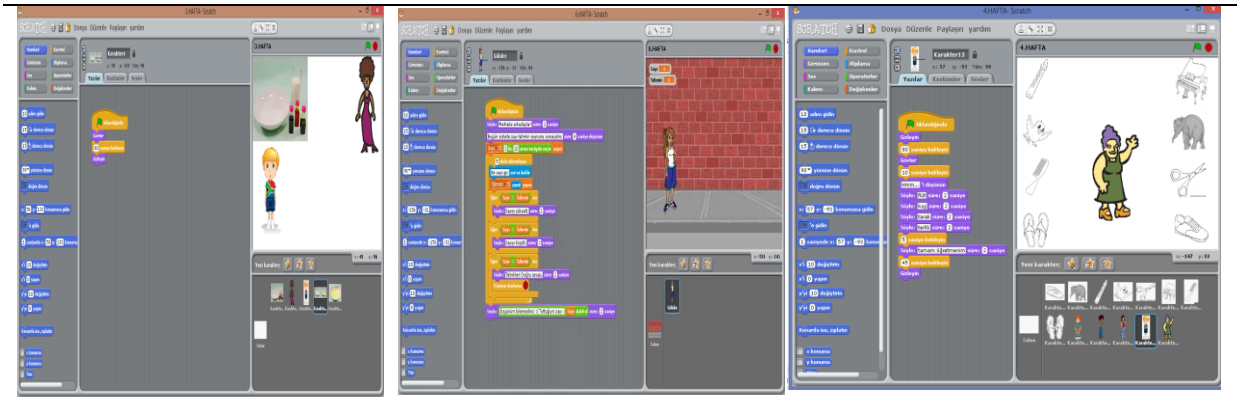
1.WEEK 4.WEEK 7.WEEK

Participants used control blocks often and used them more and more as the weeks passed. Not only did they use more control blocks, but they also diversified the content in the last few weeks. When the findings obtained from the study were examined, it was determined that the frequency and content of the control block usage became richer compared to the following weeks in the field of mathematics (at the 2nd, 4th, 6th, 8th, and 10th weeks). However, in science subjects (1st, 3rd, 5th, 7th, and 9th weeks), the frequency and content of block usage remained weaker than mathematics. They mostly used the following control blocks: *"when clicked," "wait ( ) seconds," "forever," "pause," "repeat ( )," "when sprite 6 clicked," "if ( ) then," "else," "direction," "when (key pressed)," "broadcast," "when I receive ()," "stop."*



Graph 4. Frequency of use of the control blocks

As for control blocks, some participants made significant progress, but others made moderate progress (Graph 4). For example, participant number 18 made consistent progress, while participant number 20 had ups and downs. Participant number 6 made significant progress in the last week. You can see below the Scratch projects created by one of the participants: Number 8 in the first, fourth, and tenth weeks.

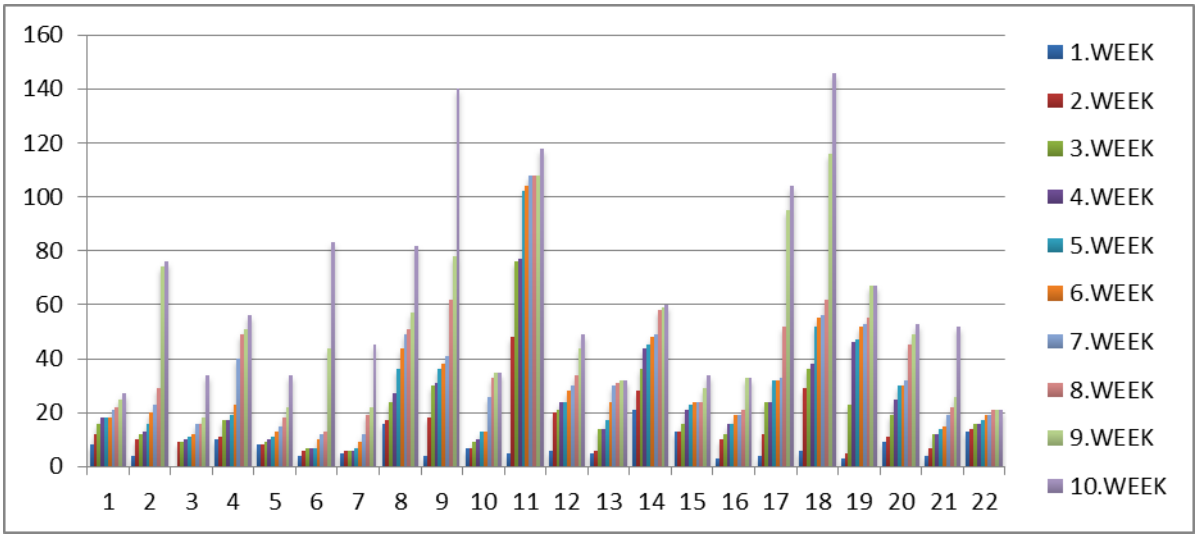


1.WEEK 4.WEEK 10.WEEK

Most participants made no progress in integrating other blocks (sound, variables, operators, etc.) into their projects. However, some participants used those blocks in their projects. It has been observed that students do not use other blocks very much in the fields of mathematics and science. However, it was determined that the frequency of use was better in the field of mathematics (at the 2nd, 4th, 6th, 8th, and 10th weeks). Eight participants (3, 8, 11, 14, 13, 16, 21, and 22) used sound blocks: *"recording, play sound… until done," "set volume to (100) %," "recording, play sound…,"* and *"play sound (soothing rain) until done."* Seven participants (1, 6, 8, 14, 15, 17, and 19) used sensing blocks: *"ask () and wait"* and *"answer."* Five participants (1, 3, 14, 15, and 19) used the operators blocks: *"pick random 1 to 10," "join," "()+()," "()=(),"* and *"()>( )."* Five participants (6, 8, 14, 15, and 19) used variable blocks: *"set the number of correct answers to ()," "set the number of incorrect answers to ()," "change the number of correct answers until ()," change the number of incorrect answers until ()," "Item 1," "conclusion," "Item 2," "number," "prediction,"* and *"number ( )."* Only one participant used pen blocks: *"erase all," "set pen color to," set pen size to ( ),"* and *"pen down."* Below are participants' Scratch projects by weeks. You can see below the Scratch projects created by one of the participants: Number 14 in the second, fifth, and tenth weeks.

2.WEEK 6.WEEK 10.WEEK

The total number of blocks was the sum of eight different types of blocks. Participants used more and more blocks throughout the week. Some participants made progress in some weeks but not in others. However, most participants became better at using the blocks in their projects as the weeks passed (Graph 5). When the findings obtained from the study were examined, it was seen that the total block usage frequency of the students in the field of mathematics (2nd, 4th, 6th, 8th and 10th weeks) improved with the following weeks. On the other hand, in science subjects (1st, 3rd, 5th, 7th, and 9th weeks), it is seen that the progress is less compared to mathematics.



Graph 5. Frequency of use of the total blocks

Most participants used a few blocks in the first weeks but used more blocks in the following weeks. They peaked, especially in the last weeks. For example, participant number 2 used very few blocks in the first weeks but made significant progress as the weeks passed. Participants 6, 7, 13, 19, and 21 used the fewest blocks in their projects in the first weeks. On the other hand, participants number 9 and 18 used the highest number of blocks in the last week. Some participants made steady progress as the weeks passed. You can see below the Scratch projects created by one of the participants: Number 9 in the third, fifth, and tenth weeks.

3.WEEK 5.WEEK 10.WEEK

Conclusion, Discussion, and Suggestions

According to the results obtained from the study, the students increased the frequency of using blocks in scratch projects over time. It was observed that the content was enriched with the increase in the frequency of block use by the students. It is seen that the students are generally better in mathematics (at the 2nd, 4th, 6th, 8th, and 10th weeks) compared to the science subjects (1st, 3rd, 5th, 7th, and 9th weeks) with the following weeks. Begosso and Da Silva (2013) conducted a study on the use of Scratch to focus on improving students' (ranging from 11 – 13 years old) problem-solving skills and logical mathematical thinking. The students prepared an activity for three months by using the state, loop, and comparison operators in Scratch to improve their programming and problem-solving skills. The results obtained from the study revealed that the students showed improvement in these areas. This study analyzed students' Scratch projects. The results showed that participants used more and more blocks in their projects and integrated them into more diverse content. They focused on the subjects of buoyancy (science) and numbers (math) the most. Some participants used more sprites, while others did not make any significant progress. Participants had a consistent attitude towards motion blocks. Some participants used more motion blocks in the last weeks compared to the first weeks. However, some others did not make any progress. Some participants did not even use motion blocks in the last few weeks. Participants mostly used control and look blocks in the first weeks but made significant progress throughout the weeks. Participants had difficulty using control blocks and synchronizing their projects in the first few weeks. In the following weeks, they were able to use control blocks and had no problems with synchronization. Meerbaum-Salant et al. (2013)

argue that Scratch allows students to develop affective skills but fails to help them internalize some concepts (variables, synchronicity, and repetition). Only a few participants used the other blocks (sound, sensing, variables, and pen). The most important result was that participants used more blocks as the weeks passed. Although they used more or less the same blocks throughout the weeks, we can still talk about progress.

The reasons for these results obtained from the study can be explained as follows. First, this course was at the end of the semester. Second, participants probably had high stress and anxiety because they had to pass many courses to graduate. Third, the students had to take into account many factors because this was the first time they had had such an experience. In other words, students are supposed to have knowledge of many different fields. For example, they should know about technology for coding and have content knowledge for science and math concepts. They should have the pedagogical knowledge to teach these concepts to their students and to prevent misconceptions. They also need to have design skills to think about all these areas of knowledge together. All of these may be the reasons why participants had difficulty using Scratch.

Limitations of the Study and Recommendations for Future Researchers

The results of the study showed that in the analysis of the projects prepared by the students in science and mathematics, there were improvements in the frequency of use of blocks by weeks and enrichment in their content. As the first limitation of our study, we can state the absence of experimental and control groups. While the results obtained show that there is progress in our study, having an experimental and a control group will help us examine the performance differences in the process. Another limitation is the sample size. Researchers who will do research in the future claim that block-based coding is easy, but we think it should take more than a semester to integrate Scratch into lessons. In addition, it can not be limited to the fields of science and mathematics but can also integrate it into different disciplines. In addition, longitudinal execution of studies in this field and planning a longer-term study can reveal whether students benefit from this application.

Ethical Approval

The data used in this study was confirmed by the researcher that it belongs to the years before 2020.

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Exploring teacher development courses in the lens of integrated STEM education: A holistic multiple case study

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Exploring teacher development courses in the lens of integrated STEM education: A holistic multiple case study

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Abstract

The implications of how teacher development courses (TDCs) should be designed for integrated STEM education are essential for in-class STEM education practices. This study compares the three TDCs accomplished to support teachers' professional development (PD) for integrated STEM education in terms of pedagogical knowledge, technological knowledge, and strategy. A holistic multiple-case study design was used in this study. Each TDC was considered a case study, and case-specific analyses were made. The findings obtained for each case were then compared. The first TDC included only computer science teachers and showed us the necessity of interdisciplinary work to enhance integrated STEM education. The second TDC demonstrated that this work could be accomplished by combining the content knowledge of teachers from various disciplines; however, the second TDC's drawbacks included identifying real-world problems, a lack of response to the engineering approach for science and mathematics teachers, and the rigidity of the collaborative working strategy. Then, we focused on the role and purpose of "T"echnology. Finally, we gave the teachers learning tasks to work collaboratively with teachers in their disciplines first and teachers from other disciplines later. This study shows how a TDC should be designed effectively to support teachers' PD for integrated STEM education.

Keywords: Professional development, Collaborative professional development, Teacher development, Integrated STEM education, STEM teachers

Introduction

In research on STEM education, one of the STEM disciplines is usually focused on (English, 2016); some studies deal with combinations of different STEM disciplines (Falloon et al., 2020; Li et al., 2020a; Ortiz-Revilla et al., 2020). STEM education projects in the USA mainly focus on separate STEM disciplines, especially mathematics (Li et al., 2020b). Likewise, approximately half of the STEM education research connects to science education when STEM education is mentioned (English, 2016). In recent years, the integration of STEM disciplines for effective STEM education has been further advocated, and the significance of "integrated STEM" education is addressed (Cheng et al., 2020; English, 2016; Johnson, 2013; Martín-Páez et al., 2019; Stohlmann et al., 2012; Thibaut et al., 2018; Zhou et al., 2022). Although STEM education emphasizes linking disciplines, how to achieve this is uncertain in curricula (Morrison et al., 2021). This is because historically, STEM disciplines have always been taught as separate disciplines at the first and secondary school level, and education at schools continues on a single discipline basis (Martín-Páez et al., 2019).

Although integrated STEM education offers great potential for students and teachers, it has some challenges due to a lack of consensus on its implementation (Thibaut et al., 2018). While effectively supporting interdisciplinary education with pedagogical techniques that enrich content and meet curriculum requirements is unknown, it is essential to support teachers' professional development (PD) in this sense, even at the beginner level (Herro & Quigley, 2017; Song, 2020). Teachers should reexamine their beliefs regarding STEM in learning and teaching and move toward interdisciplinary approaches that involve solving real-world problems (Falloon et al., 2020). Teachers' PD regarding integrated STEM education must be supported (Stohlmann et al.,

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2012). There is a tendency for studies that focus on the PD of teachers in integrated STEM education (Baker & Galanti, 2017; Estapa & Tank, 2017; Hudley & Mallinson, 2017; Kelley, Knowles, Holl, & Han, 2020; Ryu, Mentzer, & Knoploch, 2019). In light of these studies, the implications of how teacher development courses (TDCs) should be designed for integrated STEM education are essential for in-class STEM education practices.

The authors of this research have designed and implemented three TDC supported at the national level. The most important feature of these courses is that researchers from different STEM disciplines designed them, and each course was reexamined with the experiences from the previous one. TDCs aimed to develop teachers' knowledge and skills for integrated STEM education. As discussed in the literature, we also tended to work with a single discipline in the first TDC. The first one included only computer science teachers and showed us the necessity of interdisciplinary work to enhance integrated STEM education. The second TDC focused on enabling computer science, science, and mathematics teachers to collaboratively design integrated STEM lessons that focus on real-world problems by connecting STEM disciplines. Based on the experience from the first and the second courses, the third TDC focused on how teachers from different disciplines can collaborate. This study treated each of the three TDCs designed iteratively as cases. It sought to answer the question, "how should a TDC be designed effectively to support teachers' PD for integrated STEM education?".

Literature Review

Integrated STEM Education

Integrated STEM education has been discussed in Sanders's (2009) research on how STEM disciplines interact. Sanders (2009) defines integrated STEM education as learning and teaching approaches in two or more STEM disciplines and/or in a STEM discipline and one or more school subjects. Johnson's (2013, p. 367) definition is as follows: "integrated STEM education is an instructional approach, which integrates the teaching of science and mathematics disciplines through the infusion of the practices of scientific inquiry, technological and engineering design, mathematical analysis, and 21st-century interdisciplinary themes and skills". According to Falloon et al. (2020), the pedagogy and curriculum of STEM education are problem-oriented, project-based, and authentic, real-world scenarios are used as the context for learning, and multiple knowledge and skills are integrated for an activity that focuses on solving a problem, need or an opportunity. Different viewpoints on how disciplinary integration can be accomplished with multidisciplinary, interdisciplinary, and transdisciplinary approaches (English, 2016; Zhou et al., 2022). These perspectives (English, 2016) are; i) can include fundamental concepts and skills that are taught distinctly in each discipline yet are hosted within a common theme; ii) intimately associated concepts and skills from two or more disciplines can be included to deepen understandings; iii) a transdisciplinary approach can be adopted in which knowledge and skills from two or more disciplines are utilized to real-world problems and projects to form the total learning experience. Based on these definitions, three features of integrated STEM education stand out: integration of disciplines, real-world or authentic contexts, and problem-solving (Zhou et al., 2022). This study considers integrated STEM education to integrate a range of conceptual, procedural, and attitudinal contexts in STEM disciplines by linking them together to solve problems presented in authentic contexts.

STEM education improves the application skills in disciplines under its umbrella, provides implementation experience, enhances creativity and technological skills, and increases interest in these areas (Martín-Páez et al., 2019). Integrated STEM education can improve STEM motivation through integrating STEM disciplines (Cheng et al., 2020; Thibaut et al., 2018). With integrated STEM education, STEM disciplines have begun to be combined, engaged in dialogue, and integrated more efficiently in terms of education (Ortiz-Revilla et al., 2020). Integrated STEM attempts to combine science, technology, engineering, and mathematics based on the link between subjects and real-world problems in a single classroom (Stolhman et al., 2012). Integrated STEM education is considered a significant development phase on the road to a skillful future workforce and is seen as a link to future development and prosperity (Zhou et al., 2022). In this respect, it is necessary to focus on basic content information and the interdisciplinary process to ensure STEM integration and improve the profile of all disciplines (English, 2016). In this regard, further research and discussion is needed on the knowledge, experience, and background teachers need (Stolhman et al., 2012).

Teacher Development for Integrated STEM Education

Teachers play a vital role in bringing the potential of integrated STEM education into the classroom. Further research and discussion are needed for teachers to carry integrated STEM education to their classrooms. In

particular, teacher development, teaching practices, teacher competencies, and the materials required to implement integrated STEM education must be considered (Stolhman et al., 2012). While a training program that includes STEM integration for pre-service teachers contributes to their planning and implementation skills existing school practices, limited understanding of interdisciplinarity, and lack of role models have proven to be barriers (Ryu et al., 2019). Another barrier is that some disciplines, particularly mathematics and science, emphasize STEM education (Herro & Quigley, 2017). In STEM education, most publicly funded projects in the US focus on individual STEM disciplines, especially mathematics (Li et al., 2020b).

Similarly, it is stated that there is a close relationship between STEM education and science education (English, 2016). There are findings that teachers associate STEM-based activities with science, especially physics, and consider them under physics subjects (Eroğlu & Bektaş, 2016). It can be regarded as a result of teachers' focusing more on their subjects while combining different disciplines. Teachers with various disciplines struggle finding content together and spend more time planning content-specific STEM tasks than determining the content (Brown & Bogiages, 2019). Eight themes were established to support teachers to overcome these challenges: (a) time for collaboration and planning, (b) PD programs, (c) sources, (d) supportive STEM culture, (e) communication between departments, (f) more time for teaching, (g) change in teacher attitudes, (h) manageable classroom sizes (Shernoff, Sinha, Bressler, & Ginsburg, 2017).

The strategies and content of TDCs are among the factors that can be improved at the teacher level, among the factors stated above. In this context, education programs in which disciplines are integrated and 21st-century skills are associated with real-world problems are important (Kurup et al., 2019). The TDC organizers and teachers need to brainstorm and plan together (Brown & Bogiages, 2019). It is necessary to strengthen this collaboration with studies where teachers from different disciplines come together. Professional learning communities with diverse backgrounds contribute to teachers' collective knowledge and pedagogical content knowledge (Vossen et al., 2020). In summary, education programs that focus on real-world problems, link multiple disciplines, and enable teachers to work collaboratively emerge as essential elements in supporting teachers for integrated STEM (Stohlman et al., 2012).

Although strategies to increase the effectiveness of TDCs for integrated STEM have been defined in the literature, it is challenging to put them into practice and realize the expected transformation in teachers. Most teachers have never experienced such a learning experience (Morrison et al., 2021). Teachers' existing teaching habits, pedagogical competencies in the lesson planning, collaborative working skills, and individual differences regarding collaborative working can create facilitating or hindering conditions while implementing the mentioned strategies. Therefore, it is crucial to examine teachers' opinions during the implementation and make revisions accordingly. Thus, it can be ensured that education programs are improved, and PD strategies are optimized.

Present Study

Integrated STEM education is essential to ensure a fairer representation of disciplines. Failure to do so may result in incomplete learning about other disciplines under the name of STEM education. This study aims to compare the three TDCs accomplished in the last three years to support the PD of teachers for integrated STEM education in terms of pedagogical knowledge, technological knowledge, and strategy and to examine teachers' views about these programs. For this purpose, answers were sought to the following questions:

1. How has TDCs' scope for integrated STEM education changed regarding pedagogical knowledge, technological knowledge, and strategy?
2. What are the opinions and suggestions of teachers regarding TDCs?
3. What are the recommendations of the researchers to develop TDCs?

Methodology

Case studies allow for the longitudinal study of a complex situation by broadly defining and identifying its components in their natural environment. In this study, a holistic multiple-case study design was used. The holistic multiple-case design is used when a single analysis unit is being treated with more than one case. In this respect, three TDCs carried out in three consecutive years were determined as units of analysis, and each unit was handled within itself and then compared holistically. The significant advantage of examining multiple units of analysis is that evidence is provided from multiple sources, thus facilitating generalization (Yin, 2009).

Context and Participants

This study tackles three TDCs supported within the scope of national science and society practices and conducted in Turkey in 2018, 2019, and 2020. The scope of the support is to provide teachers with innovative approaches, strategies, methods, and techniques specific to the teaching profession interactively. Based on the analysis of the data obtained from each TDC, experiences gained, and observations made, the design of the TDC in the following year was improved and revised.

All three TDC were designed in modules. Each TDC has experts in the field of computer science, science, and mathematics education who work as faculty members at universities. The authors participated in the process as principal researchers and experts of these TDCs. All experts and teachers came together from different cities in Turkey. TDCs were organized as "education camps", and experts and teachers stayed together during the program. Teachers had the chance to spend time and consistently exchange ideas with experts and colleagues at breakfast, lunch, dinner, and before and after course sessions.

Figure 1. The final version of TDCs' modules

A nationwide call has been made for each TDC. In the application form, teachers were asked about their knowledge and skill levels regarding STEM education in their fields. In addition, teachers were asked to explain their ideas about integrated STEM education and their teaching practices by giving examples. Teachers applied to the program voluntarily, and participants were selected through blind review. This study consisted of teachers who participated in TDCs and worked in secondary schools in various provinces of Turkey.

TDCs were aimed at developing teachers' technological and pedagogical knowledge and skills. Fifty teachers who worked as computer science teachers participated in TDC in 2018. Forty teachers from 26 different cities with science, mathematics, and computer science participated in the program in 2019. Thirty-nine teachers from 19 provinces, science, mathematics, and computer science teachers, attended the program in 2020. Demographic information of teachers is given in Table 1.

According to Table 1, 23 of the teachers who participated in TDC I, carried out in 2018, were female, and 27 were male. When participants' education level was examined, 29 had a bachelor's degree, and 21 had a master's degree. Twenty of the teachers who participated in TDC II, conducted in 2019, were female; 20 were male; 26 had a bachelor's degree, while 14 had a master's degree. 20 of 39 teachers were female, and 19 were male, participated in TDC III in 2020. When the teachers' education levels were examined, 24 of them had a bachelor's degree, and 15 had a master's degree. All TDCs were conducted face-to-face and lasted for six days.

Table 1. Demographic information of teachers participating in TDCs

	TDC-I	TDC-II	TDC-III	Total
Field	50 Computer Science	20 Computer Science	13 Computer Science	83
		10 Mathematics	13 Mathematics	23
		10 Science	13 Science	23
Gender	23 Female	20 Female	20 Female	63
	27 Male	20 Male	19 Male	66
Education Level	29 (Bachelor's Degree)	26 (Bachelor's Degree)	24 (Bachelor's Degree)	79
	21 (Master's Degree)	14 (Master's Degree)	15 (Master's Degree)	50

Data Resources and Analysis

In the study, the education programs of each TDC, field notes were taken by the experts during course sessions, and the focus group interviews with teachers after TDCs were used. Each TDC was considered a case study in the data analysis, and case-specific analyses were made. The findings obtained for each case were then compared. The education programs were examined using document analysis. The first research question was taken as a basis for the documentation analysis, and TDCs were examined in terms of pedagogical knowledge, technological knowledge, and strategy. Data obtained from the field notes and focus group interviews were analyzed with content analysis. More than one researcher kept field notes. After each session, the researchers' notes were compared and discussed by the researchers, and the consensus was achieved. Consensus notes were accepted as data and analyzed.

At the end of each TDC, qualitative data were collected by conducting interviews with volunteer teachers using a semi-structured focus group interview form. The teachers were divided into groups of five and three separate focus group interviews were conducted. In the focus group interview form, there were questions about how TDC contributed to the participants, its suitability for teachers' interests and skills, and suggestions about how it could be more productive. Each interview lasted an average of 30 minutes. Content analysis is about finding concepts and relationships that can explain the data obtained (Yıldırım & Şimşek, 2006). The data analyzed by the content analysis were grouped under three categories:

1. Contribution of TDC to teachers
    a. Change in technological pedagogical content knowledge
    b. Gaining awareness of integrated STEM education
    c. Collaboration among colleagues
2. Teachers' intentions to use innovative methods
3. Recommendations for future TDCs

Content analysis was performed using the NVivo 12 program. The authors used an inductive method to analyze the data. The first author created a precoding list for coding by reading all the data. After that, the second author reviewed the coding and citations, and the analysis was revised. Then the coding was done again by the third author.

Reliability and Validity

Two experts in instructional technologies and science education were consulted during the development of the interview forms. Before the interview, the interview questions were reviewed and developed. The interviews were taped and then transcribed using a voice recorder. As a result, data loss is avoided. To ensure transferability of the data (Miles & Huberman, 1994), the data were thoroughly analyzed and presented with direct quotes. The names of the participants were not used in the direct transfer of data to ensure participant confidentiality. The researchers coded two randomly selected interviews separately (LeCompte & Goetz, 1982). The coders' agreement was calculated to be 87 percent. This rate indicates high consistency (Miles & Huberman, 1994).

Case Study I

Pedagogical Knowledge, Technological Knowledge, and Strategy

TDC-I adopted strategies were workshops, reflective practices, collaborative projects, and lesson planning. TDC-I content included technology integration, games and gamification, engineering design processes, design-based thinking, and interdisciplinary approaches to improving teachers' pedagogical knowledge. Workshops on robotics and Scratch were organized to enhance teachers' technological knowledge. At the end of the program, lesson plans and educational robotics projects as STEM learning activities were developed by teachers collaboratively. The teachers worked in groups of five. Experts and authors who were workshop leaders examined the teachers' artifacts and provided feedback in the process.

Case Study II

Pedagogical Knowledge, Technological Knowledge, and Strategy

In addition to the workshops, reflective practices, collaborative projects, and lesson planning included in the first TDC, peer, and self-assessment strategies were added to TDC-II. The pedagogical approaches adapted in TDC-II differed from TDC-I. In this program, teachers' pedagogical competencies for mathematical modeling and inquiry-based learning approaches were developed within the framework of the interdisciplinary teaching approach. The focus was also on improving teachers' digital competencies by using technological applications such as Algodoo, Python (artificial intelligence applications), Arduino, and Scratch in the learning and teaching process.

In this program, teachers designed integrated STEM lesson plans within the framework of the 5E model in collaboration with other teachers in their group. The teachers worked in groups of four (two computer science teachers, one science teacher, and one mathematics teacher per group). Given that shaping the learning and teaching process with a theoretical foundation and using teaching methods appropriate for this foundation will improve the process' quality (Yıldız, 2017), the 5E model, which consists of the initial words Enter/Engage, Exploration, Explanation, Elaboration, and Evaluation, and is based on the constructivist approach, was used (Bybee, 2009). Using information about their own field, each teacher assumed the position of subject mentor for the group in these arrangements.

Teachers were asked to create products based on STEM learning activities, such as programming and ICT, that they could use to solve real-world problems discussed in the lesson plans (these applications include at least web tools, block-based programming, text-based programming, and robotic programming applications). Besides, each group prepared tables for the lesson plans they designed, showing how the phases of computational thinking in computer science, mathematics, and science are realized and the connections between them. Thus, the teachers created three artifacts: *lesson plans, computational thinking tables,* and *STEM learning activities.*

Throughout the program, experts, workshop leaders, and authors provided feedback during the teachers' collaborative group work, examined the work/product/material they produced, and contributed to their improvement. The program designers prepared checklists to evaluate the teachers' outputs and used them to carry out self-assessment, peer assessment, and expert assessment. The lesson plans that integrate computer science, science, and mathematics education with an integrated STEM education approach were published as e-books as the program's output at the end of the program.

Case Study III

Pedagogical Knowledge, Technological Knowledge, and Strategy

Strategies used in the second program continued in TDC-III. This program aimed to enhance teachers' pedagogical competencies in inquiry-based learning approaches, mathematical modeling, interdisciplinary teaching approaches, and ICT integration. Based on these approaches, the focus was also on strengthening teachers' digital competencies on using technological applications such as Algodoo, Arduino, and Scratch in the learning and teaching process. In this program, a session on computer science unplugged was added instead of artificial intelligence applications. Teachers designed integrated STEM lesson plans within the framework of the 5E model collaboratively with other teachers in their groups. The teachers worked in three groups (one

computer science teacher, one science teacher, and one mathematics teacher per group). Each teacher took on the group's subject mentor role in these plans by employing the content information specific to their discipline. Teachers were asked to create products based on STEM learning activities, such as programming and ICT, that they could use to solve real-world problems discussed in the lesson plans (these applications include at least web tools, block-based programming, text-based programming, and robotic programming applications). Besides, each group prepared tables for the lesson plans they designed, showing how the phases of computational thinking in computer science, mathematics, and science are realized and the connections between them. Thus, the teachers created three artifacts: *lesson plans, computational thinking tables,* and *STEM learning activities.*

STEM education approach aims to equip students with the knowledge and skills to produce solutions to real-world problems. One of the most challenging issues for teachers in TDC-I and TDC-II was to define a real-world problem that would be subject to and trigger the teaching process and attract the curiosity and interest of the student. Based on this, the "Sustainable Development Goals (SDGs)" defined by the United Nations Development Program were used as a source in TDC-III. Teachers were asked to examine SDGs in groups and determine the subjects and learning objectives to connect with computer science, science, and mathematics teaching programs. Then, teachers were requested to define a real-world problem as a group within the framework of this subject, which requires knowledge and skills of other disciplines. Teachers were then summoned to design it as a STEM learning activity that students should solve under tackled approaches in the program and computer science teachers' programming and ICT applications. Teachers used these activities in the lesson plans they designed.

Throughout the program, experts, workshop leaders, and authors provided feedback during the teachers' collaborative group work, examined the work/product/material they produced, and contributed to their improvement. The program designers prepared checklists to evaluate the outputs prepared by the teachers. Self-assessment, peer assessment, and expert assessment were carried out using the checklists. The lesson plans that integrate computer science, science, and mathematics with an integrated STEM education approach were published as e-books as the program's output at the end of the program.

Findings

The findings begin with examining the initial case following a comparative case analysis. The second and the third cases are presented sequentially by comparing the results obtained from the previous case.

Case Study I

Teachers' Opinions and Suggestions About TDC

All of the teachers who participated in TDC-I stated that preparing a collaborative lesson plan is beneficial for in-class activities. One of the teachers said, "*I think the best part of the program is that the plans we have made will cover a whole year...*". In addition, most teachers stated that applied course sessions increased their courage to use these activities in their classroom. One teacher stated as follows:

> *"In this course, we designed lessons or prepared board games, making learning outcomes more understandable. ... Thus, we gained a comprehensive understanding."*

If teachers' opinions are generalized; they emphasized that TDC-I contributed to the exchange of views with their colleagues. Some of the teachers' statements are as follows:

> *"I think the community in this course I attended is also inspiring in terms of working with my colleagues. Seeing my friends and colleagues as part of a group has been really motivating."*

> *"...Teachers from different cities gathering in one place has shown how valuable it is to come together. We have teachers with profound knowledge here; I have learned from them as much as I have learned from the instructors..."*

Minority of the teachers expressed that allocating more time on collaboration among colleagues would contribute to the improvement of TDC:

> *".. More time could have been devoted to cooperative work. As a group, we could solve problems, meet each other, get acquainted and make a product. I would have loved to see my colleague's point of view and develop our professional network more."*

In addition, most of the teachers thought that the content should be changed so that math and science teachers' subject-matter knowledge could be added to the course:

> *"...robotics and coding, these are concepts that are always talked about. We all know programming, but a fellow teacher talked about the importance of mathematics. This showed me how to move forward in my own PD. I got some book recommendations from him and had lots of ideas about what I can do, how I can integrate them into my lessons..."*

Recommendations by researchers based on field notes

Teachers benefited from designing lesson plans and learning activities and the workshops' activities organized. In addition, it was determined that they were satisfied with working with their colleagues and felt the need to allocate more time to collaboration among colleagues. They encountered difficulties in collaborative lesson planning and designing real-world problems since content knowledge from different disciplines is required. Therefore, it was seen that there is a need to bring together teachers from other disciplines to form collaborative groups among teachers. It was observed that teachers who participated in TDC-I had expectations that more technological content should be included in the education program. Some teachers informed the researchers that there should be field experts from computer engineering in their views on this matter.

Case Study II

Teachers' Opinions and Suggestions About TDC

When teachers' opinions were examined, it was seen that they were in favor of the adopted pedagogical knowledge, technological knowledge, and strategy contributing to their understanding of integrated STEM education. If all of the opinions received from the teachers who participated in the process are summarized in general, teachers stated that course sessions that are aimed at integrating different disciplines during learning and teaching processes contributed to their knowledge and skills about;

- focusing on the process rather than the product,
- focusing on a problem rather than their disciplines,
- integrating disciplines rather than bringing them together,
- seeing the process from the student's point of view and the need to include computational thinking and algorithm as part of the process rather than a product.

Some of the teachers' views are as follows:

> *"Thanks to the interdisciplinary lesson approach, my awareness about different disciplines was raised; I realized that many outcomes can be achieved and that I needed more frequent contact with my colleagues in various disciplines."*

> *"We have learned once again that we need to work together with other disciplines. I think every subject is bound to be related to each other and should be considered when designing the curricula. I believe that with such a process, the planning process will be more successful."*

> *"Organizing a lot of information that will be a solution, making it meaningful, creating an algorithm for the operations we will do, and putting them in order (while preparing a lesson plan, thinking about what kind of algorithm we will want from the students and actually making an algorithm for this in our brains while doing this made me think of nested loops) have enabled permanent learning while understanding components."*

Most teachers indicated that they recognized that when addressing the interdisciplinary approach and planning the process with the 5E learning model, course sessions on the use of innovative methods such as inquiry-based learning, and mathematical modeling can be employed and can also effectively benefit from computational thinking and informatics.

> *"I had never done inquiry-based training before. I didn't know about modeling at all. I understood many things when these two approaches were combined in the lesson plan based on the 5E model we made recently. I am feeling more comfortable about how I can do my lessons with an interdisciplinary approach. I figured out how to incorporate other subjects into my lesson and use them truly integratively."*

> *"I can easily use the lesson plan and project we have prepared in my lesson at school. Each phase of the plan was written in detail as the group could exchange ideas, brainstorm, and make a joint decision... Using this plan in the lesson will facilitate time management and classroom management, and the permanent learning of the students will be positively affected."*

> *"It helped me to realize my deficiencies and faults in my knowledge of using the 5E model. I learned by exemplifying how I can use the three disciplines in an integrated way in my course design."*

Most of the teachers stated that they were pleased to work with the teachers from other disciplines and that at the end of the course process, they had improved in approaching learning and teaching processes from other subjects' points of view:

> *"Even though we were all from different subjects, no one withdrew into their own shell and worked by themselves. We were together at every step of the way; in this way, we worked in an integrated manner."*

> *"At first, each of us focused on our subjects. However, later on, we contributed to modeling and planning, such as a station approach. On the last day, we became a team and started noticing points that one another couldn't see."*

Teachers mostly made suggestions about forming groups to develop/improve the activity. Some of the teachers stated that creating at least one session only with teachers from the same discipline and constantly renewing groups except for the last 2 days that focus on designing lesson plans would significantly contribute to interaction and sharing. One of the teachers expressed the situation as follows:

> *"If science and mathematics teachers had thought about the same problem in their groups before the activity starting and if the groups were then united, we would have been able to observe the difference and what was discussed and planned in teachers' previous groups; teachers in different disciplines trying to combine each group's mutual thoughts could have made us see the difference in the interdisciplinary working principle a little more."*

Recommendations by researchers based on field notes

After completing TDC-II, an assessment was made on the teachers' opinions, observations of experts in the program, and field notes. It was observed that the workshop on artificial intelligence applications with an interdisciplinary approach exceeded the digital competencies of science and mathematics teachers. In addition, it was noted that teachers had difficulty identifying real-world problems that they will use while preparing their lesson plans collaboratively within the framework of the 5E model. It was determined that the one-time creation of groups for collaborative group work and the teachers working with the same groups from beginning to end limit the interaction with other teachers and the sharing of knowledge and experience.

Case Study III

Teachers' Opinions and Suggestions About TDC

Designing the learning and teaching process with the STEM education approach requires interdisciplinary knowledge and skills. Some of the views of the teachers who participated in TDC-III on interdisciplinary studies, interdisciplinary competencies, and the change and development in the program on their knowledge and understanding of collaborative working skills with teachers from different disciplines are as follows:

> *"Collaborative work was the best way to design a lesson plan covering three disciplines. Having a colleague from each subject revealed what we can and can't incorporate into the lesson plan that we dreamed of. Since 'the subject teachers know learning achievements very well, we realized our limitations and the topics we weren't knowledgeable about..."*

> *"I realized that it is possible to combine my achievements in my subject with the achievements of other disciplines and act together. I discovered that it is easier with other disciplines to plan activities for my students to solve problems in life and daily life."*
>
> *"We saw that it is impossible to solve a real-world problem through a single discipline; it should be solved by more than one discipline coming together. We saw that many unnecessary repetitions can be avoided when a problem is approached interdisciplinarity."*

Summarizing all the opinions of the teachers involved in the process, the teachers believe that when addressing the interdisciplinary approach and planning the process with the 5E learning model, course units can be used to apply innovative methods such as inquiry learning and modeling, and computational thinking and computer science can also be used effectively. Some teacher opinions supporting this situation are as follows:

> *"Seeing the importance of science and mathematics in developing common skills and integrating disciplines, it was an innovative output for me to observe where and how computing took place in the process."*
>
> *"I experienced the calculations I made only with paper and pencil in mathematics with real models and computer simulation. In this way, I integrated science and technology."*

As a result, it is understood that the teachers were satisfied with the practical activities in the program and returned from this activity with various gains. Teachers saw that they could work together with teachers from other disciplines by finding the opportunity to ensure interdisciplinary integration. It was revealed that group compliance is vital for effective collaboration and that collaboration is key to achieving interdisciplinary integration.

Some teachers made suggestions for extending the time to improve program activities. In addition, they emphasized the importance of providing preliminary information at the theoretical level to eliminate the difference in readiness among some teachers about the course. All of the teachers who took part in the interviews believed that educational resources, such as theoretical information and guidelines for program activities, should be supplied to them ahead of time. The following are some examples of this situation:

> *"First of all, it is a multi-step study that requires longer time to communicate with other subjects, understand the outputs, combine them with our outputs, and bring them together. Making an update on the duration may increase the validity of the products to be revealed."*
>
> *"In my opinion, we had too many shortcomings. I think the time given can be increased a little. In fact, the plan requested from us can be presented to us in the form of preliminary information before the theoretical course sessions are given. In this way, we can know the point we need to focus on from the beginning."*

Recommendations by researchers based on field notes

After completing TDC-III, an assessment was made on teachers' opinions, observations of experts in the program, and field notes. According to this assessment, experts and principal researchers consensus that more time should be allocated to the activities so that teachers can complete the activities in the program, placing theoretical activities at the beginning of the program and increasing the duration of course activities. In addition, an idea was put forward to organize online meeting activities that will allow teachers to get to know each other before the course for extraordinary periods, such as when the COVID-19 epidemic was experienced.

Comparison of Cases

This study compared three consecutive TDCs in pedagogical knowledge, technological knowledge, and strategy. Then, a portrait of the change and development of the programs over the years was trying to be drawn. The first TDC was designed around the needs that the authors identified and observed in their studies (Mumcu & Uslu, 2019; Uslu & Mumcu, 2020). TDC-II and TDC-III were redesigned based on the authors' research on teachers' expectations from a professional development program for integrated STEM education (Mumcu, Uslu, & Yıldız, 2022), the suggestions of the teachers who attended the first TDC, the observations made by the experts, and the field notes they took. Interviews with teachers showed an essential need for TDCs that address the integration of different disciplines and that teachers will collaborate with their colleagues from various fields.

As a result of the three TDCs, the point reached by the TDC designs in terms of technological knowledge, pedagogical knowledge, and strategy is shown in Figure 1.

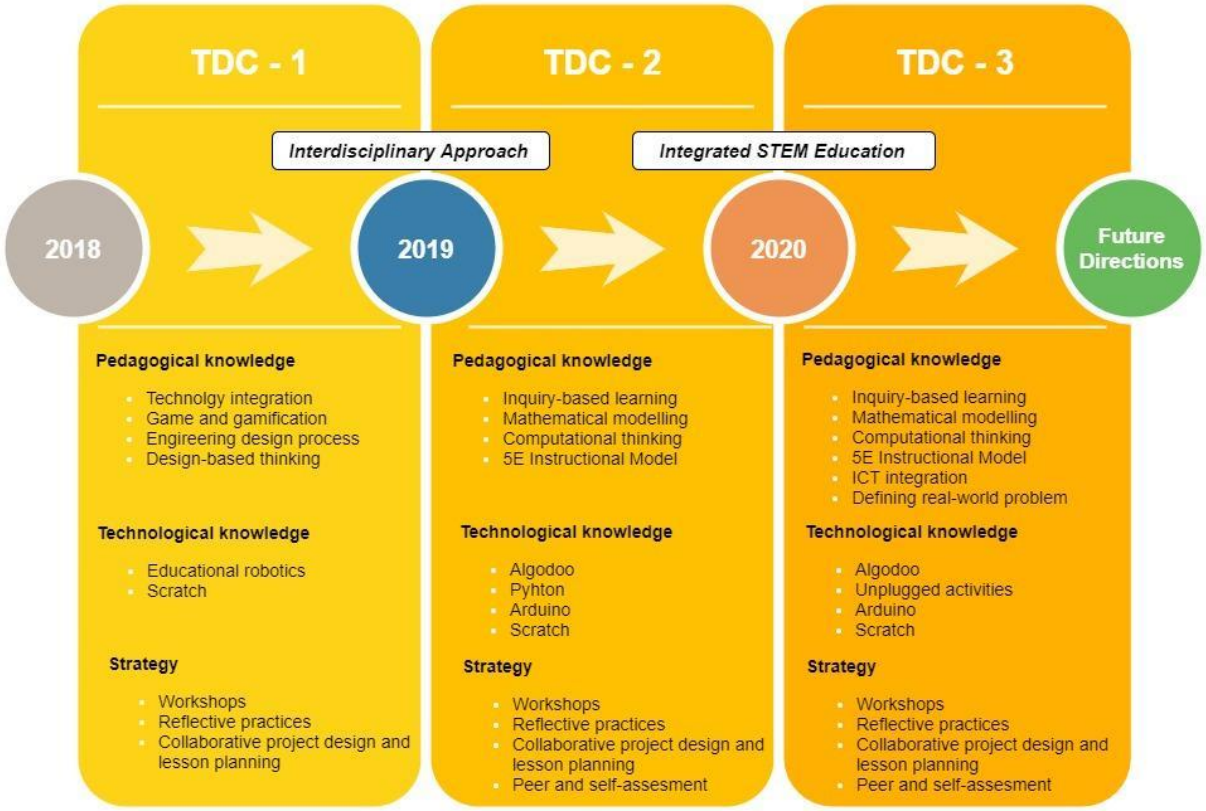

Figure 2. The change of TDCs over the years

Results and Discussion

This study examines the change of three consecutive TDCs in practice based on the needs emphasized in the literature for integrated STEM education. STEM education is based on collaboration. It distinguishes it from individual-based educational activities (Li et al., 2020a). This collaboration can occur in two situations, with other institutions and with teachers. Cooperation between schools and universities provides essential support in teachers' PD (Hamilton et al., 2021; Lehman et al., 2014). In this study, cooperation was ensured both between schools and universities and among teachers. Experts trained teachers who work actively in STEM disciplines, and teachers' PD was supported to transform theoretical knowledge into practice in schools.

The starting point of the first TDC is to nurture computer science teachers' integrated STEM teaching competencies technologically and pedagogically. However, the first TDC showed the necessity of interdisciplinary work to enhance integrated STEM education and the computation side of STEM education. For this reason, we decided to integrate science and mathematics education, which are the core disciplines of STEM, with computer science education; as of 2019, we changed the program's content. Mathematical modeling and inquiry-based learning were added to the content. Because modeling activities are based on real-world problems and require interdisciplinary associations, they are proper for integrated STEM education (Sevinç, 2019). Although the developed model is expressed with mathematical symbols and representations, it requires evaluating, processing, and blending of information from different disciplines, especially science and computer science. As inquiry-based learning emerges in science education, it may appear relevant only to this field, but it is not limited and occurs in mathematical or technological concepts (Thibaut et al., 2018). Inquiry-based learning is defined as one of the five fundamental principles of integrated STEM (Thibaut et al., 2019).

Science and mathematics are core disciplines of the STEM acronym. Besides, with the emergence of computational branches of sciences such as computational biology and astronomy, the sciences are becoming more computational (Ketelhut et al., 2020). In this respect, STEM education researchers recognize the importance of integrating computational thinking into the curriculum (Barr & Stephenson, 2011; Sengupta et al.,

2013); however, computation at the K-12 level remains a particular field of study (Dickes et al., 2020; Arastoopour-Irgens et al., 2020). Computational thinking makes science and mathematics education more compatible with current professional practices in these fields (Weintrop et al., 2016). Shute et al. (2017) emphasize that STEM curricula should strengthen computational thinking. So, we also focused on the integration of computational thinking into STEM education.

Due to the nature of integrated STEM education, we included science teachers, mathematics teachers, and computer science teachers in TDC-II and TDC-III. The second TDC showed that this work could be done by integrating teachers' content knowledge from different disciplines with the products prepared by teachers in terms of interdisciplinary work and integrated STEM education. Integrated STEM learning activities should support students' integrating knowledge and skills from STEM disciplines as they tackle real-world problems, and this integration should be reflected in how students are assessed (Newhouse, 2017). The teacher needs to plan the learning-teaching process in detail. However, it has been seen that most of the teachers who stated that they did interdisciplinary practices could not design an interdisciplinary lesson, despite having a positive attitude towards it (An, 2017; Gürkan, 2019). The disadvantages of the second TDC were identifying real-world problems, the lack of response to the engineering approach for science and mathematics teachers, and the rigidity of the collaborative working strategy.

In the third TDC, we primarily focused on the ICT integration and the role and purpose of using "T"echnology in integrated STEM education. Then, we used the SDGs as a resource to identify a real-world problem that will be the subject of the learning and teaching process and attract the students' attention and curiosity. Thus, we worked on how teachers would determine the content that would combine different disciplines. Finally, we gave the teachers learning tasks to work collaboratively with teachers in their disciplines first and teachers from other disciplines later. Each program's primary and common point is to produce products that will guide teachers' in-class practices and increase pedagogical and technological competencies. At the end of each program, lesson plans were designed by the teachers through collaborative group work, and the prepared lesson plans were published as e-books. Ensuring a talented generation interested in STEM requires establishing teams of teachers working together with an integrated approach based on cross-curricular teaching and learning (Kurup et al., 2019). As a result, these programs encouraged teachers responsible for their lessons at school and who received teacher education on the single-discipline level to work collaboratively with their colleagues, focus on interdisciplinary education, and produce with teachers from different disciplines. TDCs demonstrated that integrated STEM education could be accomplished by integrating teachers' content knowledge from various disciplines. Becker and Park (2011) found in their meta-analysis study on the effects of integrative approaches on STEM subjects that students did better when they learned STEM in an integrated way.

As a collaboration with external stakeholders such as universities, collaboration among teachers is vital in STEM education for schools (Herro & Quigley, 2017). In addition to sharing the workload of planning and implementation, teachers, as a group who support each other (Asghar et al., 2012), recognize the importance of collaboration (Hamilton et al., 2021). Herro and Quigley (2017) stated that collaboration in STEM education-related to interdisciplinary teaching is necessary to understand its content, connect with experts, and enable discussions to overcome future challenges. Teachers' confidence, efficacy, and perceptions towards STEM education increase when they work together and harmonize their standards (Nadelson et al., 2013). There is a limited number of studies on teachers from different disciplines working collaboratively to create, implement and disseminate an integrated STEM curriculum (Balgopal, 2020). In light of the STEM studies conducted in Turkey, it is found that TDCs are insufficient in terms of integrated STEM education, learning activities, and measurement (Guenbatar & Tabar, 2019), and it is recommended to increase STEM and STEM -based instructional activities and expand the content and scope of TDCs (Eroğlu & Bektaş, 2016). The TDCs discussed in this study enable teachers from three disciplines to use each other's knowledge within the scope of integrated STEM education. In this respect, the following points were taken into consideration as the main characteristics of an effective interdisciplinary TDC in the study (Margot & Kettler, 2019; Asghar et al., 2012):

- Bringing together teachers from different disciplines, not based on a single discipline
- Developing teachers' skills in designing learning-teaching processes integrating disciplines and guiding their classroom practices
- Encouraging teachers to work in collaboration with other teachers
- Doing tasks allow teachers to interact interdisciplinary throughout the program

In short, teachers stated that they experienced a positive development in their knowledge and understanding due to the programs, increased their awareness by developing different perspectives, and nurtured each other by exchanging ideas with their colleagues. It was concluded that the teachers were willing to transfer their

experiences in TDCs to in-class practice. Teachers also stated that they gained many achievements from the group work they participated in with their colleagues and intended to keep in touch. In addition, it was determined that TDC activities guide and contribute to teachers' graduate studies.

Conclusion & Implications

The study presents tips on STEM teacher development in terms of technology, pedagogy, and content dimensions. The fact that STEM education is process-oriented rather than product-oriented offers remarkable findings on integrating disciplines, the versatility of STEM pedagogy, and the role of technology. In addition, the common emphasis of all three TDCs is how vital collaboration, communication, and group cohesion among the teachers during the program is. It was found that group cohesion is vital for effective collaboration, and collaboration plays a crucial role in ensuring interdisciplinary integration. It was also found that teachers' expertise in their subjects is an essential factor in the collaborative working process.

With the study, the authors aimed to establish a link from practice to theory by examining how theoretical knowledge corresponds in practice in the light of integrated STEM education based on teacher education. This study is expected to shed light on studies focusing on the PD of teachers for integrated STEM education. Different collaboration methods and strategies to increase group cohesion adopted in the TDCs for integrated STEM education in future studies will contribute significantly to the literature. Teachers' taking an initial STEM education is an essential factor; there is also a need for future studies to be carried out within the scope of the sustainability of PD. Among the authors ' aims are organizing studies that support sustainable PD for teachers who participated in the program.

Limitations

All Case 1 participants are computer science teachers, while Case 2 and 3 participants are computer science, science, and mathematics teachers. Authors took part in all TDCs. However, due to many modules and diverse content, experts working as faculty members at universities took part in some modules. Since each TDC is designed as a training camp, the training period is limited to 1 week.

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Author (s) Contribution Rate

FM, NAU and BY contributed equally to designing of and conducting the research and collecting the data. FM and NAU analyzed the data and FM and FO created the figures. FM carried out the literature review, wrote and prepared the manuscript. NAU provided insight and editing of the manuscript. FM and FO contributed equally the discussion and conclusion parts of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval

Written informed consent was obtained from all participants before the study. The study was conducted by considering other ethical principles.

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Analyzing TALIS Indicators and PISA Results with Data Envelopment: Comparison of EMS, DEAP, and R Software

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Analyzing TALIS Indicators and PISA Results with Data Envelopment: Comparison of EMS, DEAP, and R Software

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Abstract

The Teaching and Learning International Survey (TALIS) and the Programme for International Student Assessment (PISA) are large-scale measurements about teaching and learning. There is a link between TALIS indicators and PISA results. We investigated which countries are effective according to TALIS indicators as inputs and PISA 2015 mathematics, scientific, and reading literacy scores as outputs in this research. Common 24 countries' data from TALIS 2013 and PISA 2015 were analyzed. Data envelopment analysis was used in this quantitative research. Belgium, Denmark, Finland, Italy, Korea, Mexico, Netherlands, Norway, and Portugal were effective countries in EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software according to the input-oriented Charnes, Cooper, and Rhodes (CCR) model. Belgium, Canada, Denmark, Estonia, Finland, Italy, Japan, Korea, Mexico, Netherlands, Norway, and Portugal were effective countries in EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software according to the input-oriented Banker, Charnes, and Cooper (BCC) model. The results obtained from the BCC and CCR model differ partially. Italy and Norway should be taken as references mostly by ineffective countries for getting better PISA scores according to both models analyzing with EMS 1.3, DEAP-XP 2.1, and R-4.1.3.

Keywords: TALIS, PISA, Efficiency, Data envelopment analysis

Introduction

One of the most important factors affecting the learning, shaping, and development of students in education is undoubtedly the qualifications of the teachers (Boonen, Van Damme & Onghena, 2014, p. 126; Buddin & Zamarro, 2009, p.103; Ingersoll & Collins, 2017, p. 75). Recently, the relationships between many variables related to teachers and student achievement have been revealed by researchers. The first of these variables related to teachers is the qualifications of teachers' background ("such as teachers' degree, certification, coursework, college ratings, teaching experience, and teachers' test scores"). The second is variables related to teachers' beliefs and attitudes (such as teachers' job satisfaction, and teachers' self-efficacy). The last one is the variables related to the classroom practices of teachers (Boonen et al., 2014, p. 126-127). The Organisation for Economic Co-operation and Development's (OECD) TALIS collects international teacher qualifications and education data. In the 2013 application, the second cycle of TALIS, information was provided for useful and comparable policies by considering learning and teaching conditions (Rutkowski, Rutkowski, Bélanger, Knoll, Weatherby, & Prusinski, 2013, p. 5). The main aim of the TALIS program is to increase the international knowledge available to OECD countries and partner countries about teachers, teaching, and the effects of teachers on students' learning (Rutkowski et al., 2013: p. 7). Educational background and readiness for teachers' jobs; their professional development, instructional and professional practices; self-efficacy and job satisfaction; school leadership, feedback systems, and school climate issues are discussed at TALIS for many countries' economies (Ainley & Carstens, 2018, p. 4).

The OECD's PISA measures the reading, mathematics, and science literacy of 15-year-old students in three years, taking into account the skills they will use daily (OECD, 2016, p. 25). Internationally comparable data on student achievement in PISA are collected with items that can answer the question "What is important for citizens to know and be able to do?" and student questionnaires (Gurria, 2016, p. 22). Questionnaires in TALIS

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are also optionally applied in PISA sampled schools, creating a TALIS-PISA link (Ainley & Carstens, 2018, p. 4). In this way, it enables scientific research to be carried out on common data by establishing a connection between the achievement status of students and teacher qualifications. Efficacy analysis was conducted for 24 different countries using the link between TALIS and PISA in the present study. Indicators of teacher job satisfaction and self-efficacy perception were utilized as input variables in the study, accounting for TALIS data, while PISA mathematics, science, and reading literacy scores were taken into consideration as output variables.

Teachers' Job Satisfaction and Students' Performance

It has been seen that there are many definitions of job satisfaction in the literature. "Job satisfaction is the pleasurable state resulting from the appraisal of one's job as achieving emotional or facilitating the achievement of one's job values" (Locke, 1969, p. 316). Job dissatisfaction is a dissatisfied emotional state that prevents one's job from reaching one's job values or devaluing the job. Job satisfaction and dissatisfaction are a function of the perceived relationship between what one wants from their job and the perception that it offers or requires it (Locke, 1969, p. 316). Two main components in teacher job satisfaction are "job comfort and job fulfillment". The former emphasizes how satisfactory the job conditions are for an individual, while the latter expresses the degree of satisfaction with one's achievements within the meaningful aspects of the job (Evans, 1997, p. 327).

Variables related to job satisfaction such as "teachers who don't believe that the teaching profession is valued in society (%)" and "teachers who are not satisfied with their job (%)" were measured in TALIS 2013. There are many studies on the relationship between job satisfaction and job performance (e.g., Iqbal, Fakhra, Tahir, & Shabbir, 2016; Locke, 1970; Judge, Thoresen, Bono, & Patton, 2001; Pushpakumari, 2008). In addition, it is still a matter of debate whether job satisfaction leads to high performance or whether high performance leads to job satisfaction (Luthans, 2000, p. 167; Judge et al., 2001, p. 378; Pushpakumari, 2008, p. 91).

In their research using ex-post facto research design, Osagie and Akinlosotu (2017, p. 53) revealed that teachers' performance at work affects student success with a dual-causality relationship. High job satisfaction positively affects the school, teachers, and students (Ainley & Carstens, 2018, p. 44). Job satisfaction affects work performance and teachers' affective qualities such as self-efficacy, attitude, and motivation (Caprara, Barbaranelli, Steca, & Malone, 2006; Klassen, Bong, Usher, Chong, Huan, Wong, & Georgiou, 2009). In our research, "Teaching time per week (hours)" is also considered as an input variable. Studies have found that teachers' job satisfaction decreases as the teacher's weekly course hours increase (Yerdelen, Sungur, & Klassen, 2016, p. 147).

Teachers' Self-Efficacy Beliefs and Students' Performance

It has been proven that teacher efficacy is strongly associated with student outcomes, such as achievement, motivation, and self-efficacy beliefs, as well as meaningful educational outcomes such as teachers' persistence, enthusiasm, and instructional behavior (Tschannen-Moran & Hoy, 2001, p. 783). Teacher self-efficacy is expressed as "the belief of teachers in their abilities to organize and carry out the actions necessary to produce the given outcomes" (Bandura, 1997, p. 3; Tschannen-Moran, Hoy, & Hoy, 1998, p. 233). Self-efficacy is a concept that Bandura initially articulated in his 1977 article "Self-Efficacy: Toward a Unifying Theory of Behavioral Change," which is connected to Bandura's social cognitive theory. p. 207; Tschannen-Moran et al., 1998). Two ideas that are easily mistaken are self-efficacy and self-confidence. Self-efficacy and self-confidence are two quite different ideas, claims Bandura (1997, p. 11). While the perception of self-efficacy is the judgment of personal capacity, self-confidence is the judgment of self-worth (Bandura, 1997, p. 11).

Self-efficacy beliefs of teachers affect their performance at work and so student success (Caprara et al., 2006; Perera & John, 2020; Tschannen-Moran & Hoy, 2001; Tschannen-Moran et al., 1998; Zee & Koomen, 2016). Perceived self-efficacy has guiding effects on not only the choice of activities but also the ultimate success through expectations, it can also affect coping efforts. Efficacy expectations determine how much effort people will expend and how long they will persist in facing obstacles and deterrent experiences. The stronger the perceived self-efficacy, the greater the effort (Bandura, 1977, p. 194).

Personal self-efficacy expectations are derived from four primary sources of information: performance achievements, verbal persuasion, vicarious experience, and physiological states (Bandura, 1977, p. 191). Teacher self-efficacy is affected by many factors, such as teaching experience (Wolters & Daugherty, 2007). As self-efficacy increases, job satisfaction and student academic success are also positively affected (Bandura, 1977; Caprara et al., 2006; Perera & John, 2020; Zee & Koomen, 2016). The findings of 40 years of research on teacher self-efficacy were compiled by Zee and Koomen (2016, p. 981) who found that teacher self-efficacy

includes students' academic adjustment, teacher behavior patterns and practices related to classroom quality, and teachers' psychological well-being, including personal achievement, job satisfaction, and commitment. They found that it showed positive associations with the underlying factors. In TALIS, "teachers who believe they can help their students to value learning (%)" and "teachers who believe they can help their students to think critically (%)"indicators were considered as input variables within the scope of the research. Critical thinking is one of the competencies required for success in students' daily life, academic life and business life (Bezanilla, Fernández-Nogueira, Poblete, & Galindo-Domínguez, 2019, p. 1; Franco, Costa, Butler, & Almeida, 2017, p. 707). In this respect, it is important to reveal teachers' self-efficacy perceptions about helping students think critically.

Aim of Recent Research

It aims to determine which of the 24 countries participating in the TALIS 2013 and PISA 2015 is effective according to the BCC and CCR model when the TALIS 2013 indicators are considered inputs and PISA 2015 mathematics, scientific, and reading literacy are considered as outputs in this study. It is aimed to reveal which effective countries should be taken as a reference by which ineffective countries. The research is important because it establishes a connection between the international TALIS and PISA application, performs an efficiency analysis, and reveals the relationship between teacher qualifications and student achievement with data envelopment analysis. There are many free software for data envelopment analysis. When different software was used, the results obtained may differ partially. Therefore, it is important to compare different software in data envelopment analysis. The findings obtained from three free software frequently used in data envelopment analysis were also compared within the scope of the research. In line with the purpose of the research, answers to the following questions were sought:

1. Which countries are effective according to TALIS indicators ("teaching time per week (hours), teachers who don't believe they can help their students to value learning (%), teachers who don't believe they can help their students to think critically (%), teachers who don't believe that the teaching profession that taking is valued in society (%), teachers who are not satisfied with their job (%)") taken as inputs and PISA 2015 mathematics, scientific and reading literacy taken as outputs, based on BCC and CCR model using EMS 1.3, DEAP-XP 2.1 and R-4.1.3 software?

2. Which effective countries should be referenced according to TALIS indicators ("teaching time per week (hours), teachers who don't believe they can help their students to value learning (%), teachers who don't believe they can help their students to think critically (%), teachers who don't believe that the teaching profession that taking is valued in society (%), teachers who are not satisfied with their job (%)") taken as inputs and PISA 2015 mathematics, scientific and reading literacy taken as outputs, based on BCC and CCR model using EMS 1.3, DEAP-XP 2.1 and R-4.1.3 software?

3. How were slack values based on BCC, and CCR model analyzed with EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software?

4. How do the findings differ when using EMS 1.3, DEAP-XP 2.1, and R-4.1.3?

Method

Research Design

This study is based on a survey research and seeks to compare the efficacy of 24 different countries. In survey model research, the researcher seeks to learn about current conditions (Fraenkel, Wallen, & Hyun, 2012).

Sample

Approximately 540 000 students from 72 countries participated in the PISA 2015 assessment, representing 29 million 15-year-old students (Gurria, 2016, p. 3). 20 teachers from approximately 200 schools from each country participating in the TALIS 2013 assessment were included in the sample (Rutkowski et al., 2013, p. 38).

24 out of 72 participating countries and economies participated in the PISA 2015 and TALIS 2013 assessments. These countries are Australia, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Iceland, Israel, Italy, Japan, Korea, Latvia, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, United Kingdom.

Data Collection

Research data were accessed from the website of OECD statistics ("https://stats.oecd.org/") in 2018. The source of the input and output variables used in the research was given in Table 1.

Table 1. Input and output variables

Variables	Explanation	References
I1	Teaching time per week (hours)	TALIS 2013
I2	Teachers who don't believe they can help their students to value learning (%)	TALIS 2013/ Teachers' self-efficacy
I3	Teachers who don't believe they can help their students to think critically (%)	TALIS 2013/ Teachers' self-efficacy
I4	Teachers who don't believe that the teaching profession is valued in society (%)	TALIS 2013/ Teachers' satisfaction with their jobs
I5	Teachers who are not satisfied with their job (%)	TALIS 2013/ Teachers' satisfaction with their jobs
O1	PISA 2015 Math Average Score	PISA 2015
O2	PISA 2015 Science Avarage Score	PISA 2015
O3	PISA 2015 Reading Average Score	PISA 2015

Note: 'O' represents output, and 'I' represents input variables

Data Analysis

Data envelopment analysis (DEA) has been developed as one of the strong quantitative, analytical tools for measuring and evaluating performance by Charnes, Cooper and Rhodes. Data envelopment analysis (DEA) evaluates the performance of a set of similar entities called decision-making units (DMUs), which convert multiple inputs into multiple outputs with a "data-oriented" approach (Cooper, Seiford, & Zhu, 2004, p. 1). There are two main models in data envelopment analysis: CCR model (Charnes, Cooper and Rhodes, 1978) and BCC model (Banker, Charnes & Cooper, 1984). In this research, we used data envelopment analysis with both models.

Data envelopment analysis (DEA) measures the total technical efficiency of the decision-making units with the assumption of the constant return to scale (CRS) in CCR model. Banker, Charnes, and Cooper modified this assumption with a variable return to scale (VRS) in BCC model (Banker, Charnes, and Cooper, 1984). CCR and BCC models have two types called the input and output-oriented models. We used the input-oriented CCR model which is the most appropriate input composition to produce a certain output composition most effectively in this research. An inefficient decision-making unit (DMUs) can be made more efficient by representation by DEA with a proportional reduction of inputs (Cooper, Seiford, & Zhu, 2004, p. 15).

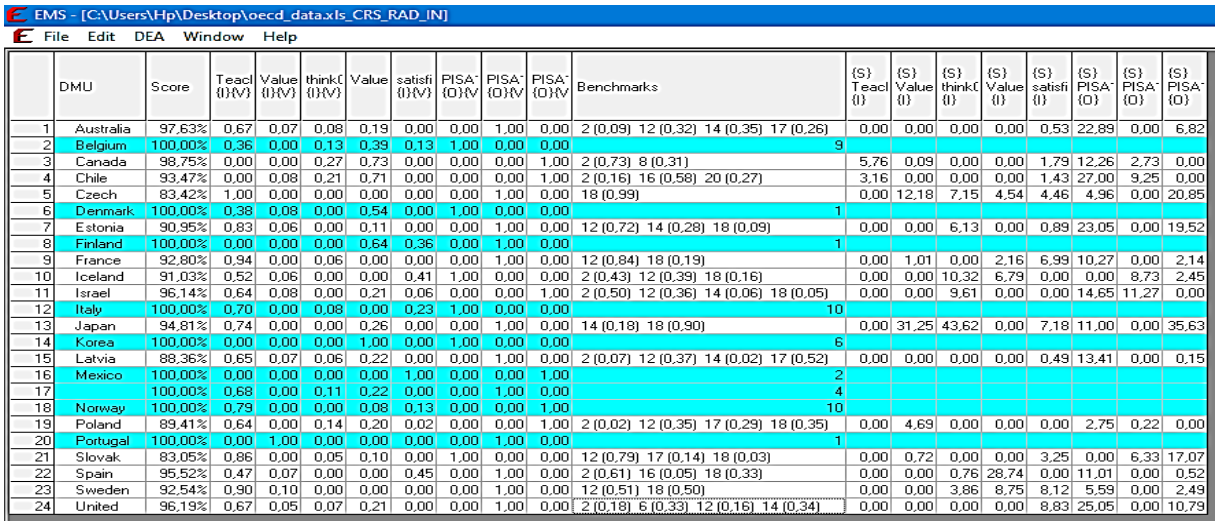
The research was carried out by following 8 steps. In the first step, as the number of DMUs decreases and the number of inputs and outputs increases, the accuracy level of data envelopment analysis will decrease (Khezrimotlagh, Cook, & Zhu, 2021, p. 529), 24 decision-making units were selected as a suitable number of DMUs. In the second step, using the literature review, 5 input and 3 output variables were selected. In the third step, by paying attention to the accessibility and reliability of the data, it worked with OECD's data that the OECD tested its reliability. As the fourth step focuses on increasing efficiency by reducing the inputs without changing the output level, it was decided to analyze the data with CCR under constant return to scale and BCC under variable return to scale assumption, considering both assumptions from input-oriented models. In the fifth step, the effectiveness of 24 countries was examined using three different software. In the sixth step, reference groups were interpreted for ineffective countries. In the seventh step, we found which country can be referenced for ineffective DMUs. According to the three software packages utilized in the research, the methods for the inquiry were chosen, and the slack values in the inputs and outputs were investigated. The results were then interpreted.

EMS 1.3, DEAP-XP 2.1, and R-4.1.3 (R Core Team, 2021) software were used to analyze the data. "deaR" package was used in R-4.1.3 (R Core Team, 2021) software. Information about the softwares used in data

analysis and data analysis steps were explained below.

Efficiency Measurement System (EMS) 1.3

EMS is a free user-friendly data envelopment analysis software designed for Windows 9x/NT. The last version of EMS was 1.3. Determining the input and output data is critical for data envelopment analysis. EMS software performs analysis on MS Excel or text format files. EMS can perform data envelopment analysis on 5000 DMUs with approximately 40 inputs and outputs (Scheel, 2000). Graphics are not provided in this software. Figure 1 shows the outputs of the data envelopment analysis performed in the CCR model with EMS 1.3.



EMS - [C:\Users\Hp\Desktop\oecd_data.xls_CRS_RAD_IN]

File Edit DEA Window Help

	DMU	Score	Teacl {I}{V}	Value {I}{V}	think{ {I}{V}	Value	satisfi {I}{V}	PISA {O}{V	PISA {O}{V	PISA {O}{V	Benchmarks	{S} Teacl {I}	{S} Value {I}	{S} think{ {I}	{S} Value {I}	{S} satisfi {I}	{S} PISA {O}	{S} PISA {O}	{S} PISA {O}
1	Australia	97,63%	0,67	0,07	0,08	0,19	0,00	0,00	1,00	0,00	2 (0,09) 12 (0,32) 14 (0,35) 17 (0,26)	0,00	0,00	0,00	0,00	0,53	22,89	0,00	6,82
2	Belgium	100,00%	0,36	0,00	0,13	0,39	0,13	1,00	0,00	0,00	9								
3	Canada	98,75%	0,00	0,00	0,27	0,73	0,00	0,00	0,00	1,00	2 (0,73) 8 (0,31)	5,76	0,09	0,00	0,00	1,79	12,26	2,73	0,00
4	Chile	93,47%	0,00	0,08	0,21	0,71	0,00	0,00	0,00	1,00	2 (0,16) 16 (0,58) 20 (0,27)	3,16	0,00	0,00	0,00	1,43	27,00	9,25	0,00
5	Czech	83,42%	1,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	18 (0,99)	0,00	12,18	7,15	4,54	4,46	4,96	0,00	20,85
6	Denmark	100,00%	0,38	0,08	0,00	0,54	0,00	1,00	0,00	0,00	1								
7	Estonia	90,95%	0,83	0,06	0,00	0,11	0,00	0,00	1,00	0,00	12 (0,72) 14 (0,28) 18 (0,09)	0,00	0,00	6,13	0,00	0,89	23,05	0,00	19,52
8	Finland	100,00%	0,00	0,00	0,00	0,64	0,36	0,00	1,00	0,00	1								
9	France	92,80%	0,94	0,00	0,06	0,00	0,00	0,00	1,00	0,00	12 (0,84) 18 (0,19)	0,00	1,01	0,00	2,16	6,99	10,27	0,00	2,14
10	Iceland	91,03%	0,52	0,06	0,00	0,00	0,41	1,00	0,00	0,00	2 (0,43) 12 (0,39) 18 (0,16)	0,00	0,00	10,32	6,79	0,00	0,00	8,73	2,45
11	Israel	96,14%	0,64	0,08	0,00	0,21	0,06	0,00	0,00	1,00	2 (0,50) 12 (0,36) 14 (0,06) 18 (0,05)	0,00	0,00	9,61	0,00	0,00	14,65	11,27	0,00
12	Italy	100,00%	0,70	0,00	0,08	0,00	0,23	1,00	0,00	0,00	10								
13	Japan	94,81%	0,74	0,00	0,00	0,26	0,00	0,00	1,00	0,00	14 (0,18) 18 (0,90)	0,00	31,25	43,62	0,00	7,18	11,00	0,00	35,63
14	Korea	100,00%	0,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	6								
15	Latvia	88,36%	0,65	0,07	0,06	0,22	0,00	0,00	1,00	0,00	2 (0,07) 12 (0,37) 14 (0,02) 17 (0,52)	0,00	0,00	0,00	0,00	0,49	13,41	0,00	0,15
16	Mexico	100,00%	0,00	0,00	0,00	0,00	1,00	0,00	0,00	1,00	2								
17		100,00%	0,68	0,00	0,11	0,22	0,00	0,00	1,00	0,00	4								
18	Norway	100,00%	0,79	0,00	0,00	0,08	0,13	0,00	0,00	1,00	10								
19	Poland	89,41%	0,64	0,00	0,14	0,20	0,02	0,00	0,00	1,00	2 (0,02) 12 (0,35) 17 (0,29) 18 (0,35)	0,00	4,69	0,00	0,00	0,00	2,75	0,22	0,00
20	Portugal	100,00%	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	1								
21	Slovak	83,05%	0,86	0,00	0,05	0,10	0,00	1,00	0,00	0,00	12 (0,79) 17 (0,14) 18 (0,03)	0,00	0,72	0,00	0,00	3,25	0,00	6,33	17,07
22	Spain	95,52%	0,47	0,07	0,00	0,00	0,45	0,00	1,00	0,00	2 (0,61) 16 (0,05) 18 (0,33)	0,00	0,00	0,76	28,74	0,00	11,01	0,00	0,52
23	Sweden	92,54%	0,90	0,10	0,00	0,00	0,00	0,00	1,00	0,00	12 (0,51) 18 (0,50)	0,00	0,00	3,86	8,75	8,12	5,59	0,00	2,49
24	United	96,19%	0,67	0,05	0,07	0,21	0,00	0,00	1,00	0,00	2 (0,18) 6 (0,33) 12 (0,16) 14 (0,34)	0,00	0,00	0,00	0,00	8,83	25,05	0,00	10,79

Figure 1. Screenshot for DEA in EMS Software

Data Envelopment Analysis Program (DEAP) 2.1

DEAP 2.1 is one of the free software used in data envelopment analysis. Data file, output file, and several DMUs, periods, output, and inputs must be specified in the DEAP 2.1 txt format instruction file. Regarding the model used, information about being input-output oriented and suitable for CCR or BCC model should be specified in the instruction file, and the software should be opened. A data file should be constructed with the name written in the instruction file (See Figure 2, EG1-dta.txt). The generated file name should be written in the instruction file name section of the software. A screenshot of the analysis with the sample CCR model was given in the figure. A limitation of this software is that graphics are not provided. Figure 2 shows the instruction and data files of the data envelopment analysis performed in the CCR model with the DEAP 2.1.

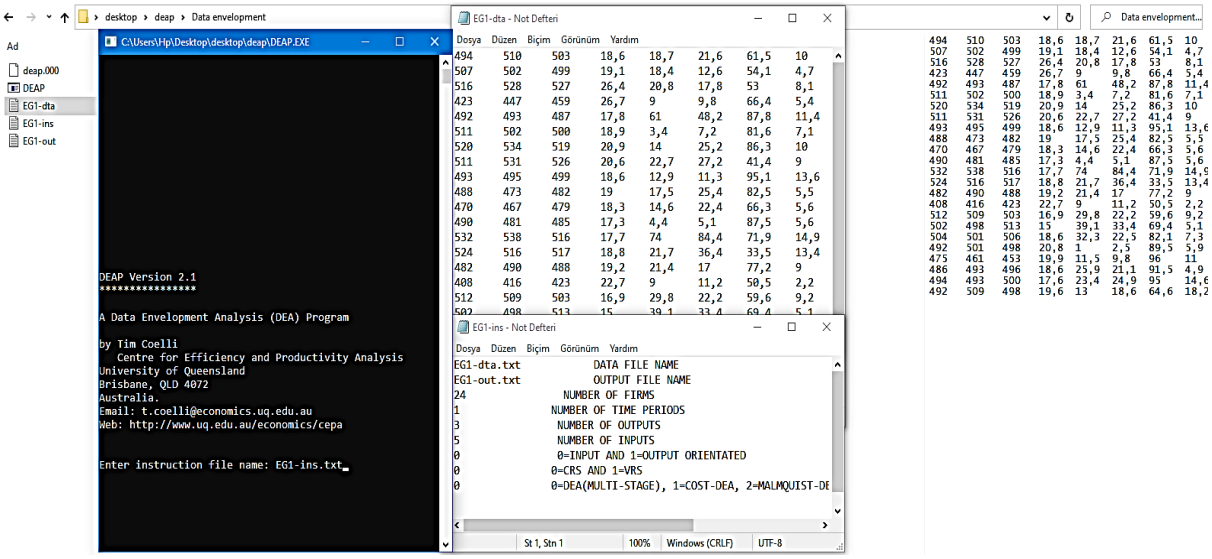


Figure 2. Screenshot for DEA in DEAP Software

R 4.1.3

R is free open-source software. 4.1.3 version has been used since the most up-to-date version of R software is 4.1.3. In this research, data envelopment analysis was performed with the "deaR" package in R software. While performing data analysis, the package used with the "install.packages("deaR")" command was installed firstly. Then the "dear" package was activated with the "library("deaR")" command. The "setwd" command was used to work in a folder. "data<-read.table("oecd.csv",header = T, sep = ";")" command introduced oecd.csv data file. Input and output variables were introduced with the command "data_example <- read_data(data, inputs = 2:6, outputs = 7:9)". Results for input-oriented CCR model, "result <- model_basic(data_example, orientation = "io", rts ="crs")" command used and "result <- model_basic(data_example, orientation = "io", rts ="vrs")" command used for input-oriented BCC model. The commands "rts(result)", "efficiencies(result)", "slacks(result)", "summary(result, export excel = TRUE)", "plot(result)", "eff(result)", "targets(result)" were used to obtain the findings and graphics. Many visualizations related to data envelopment analysis can be obtained in R. In the figure 3, the analysis codes of the CCR model and the screenshot of the R-4.1.3 software were shared.

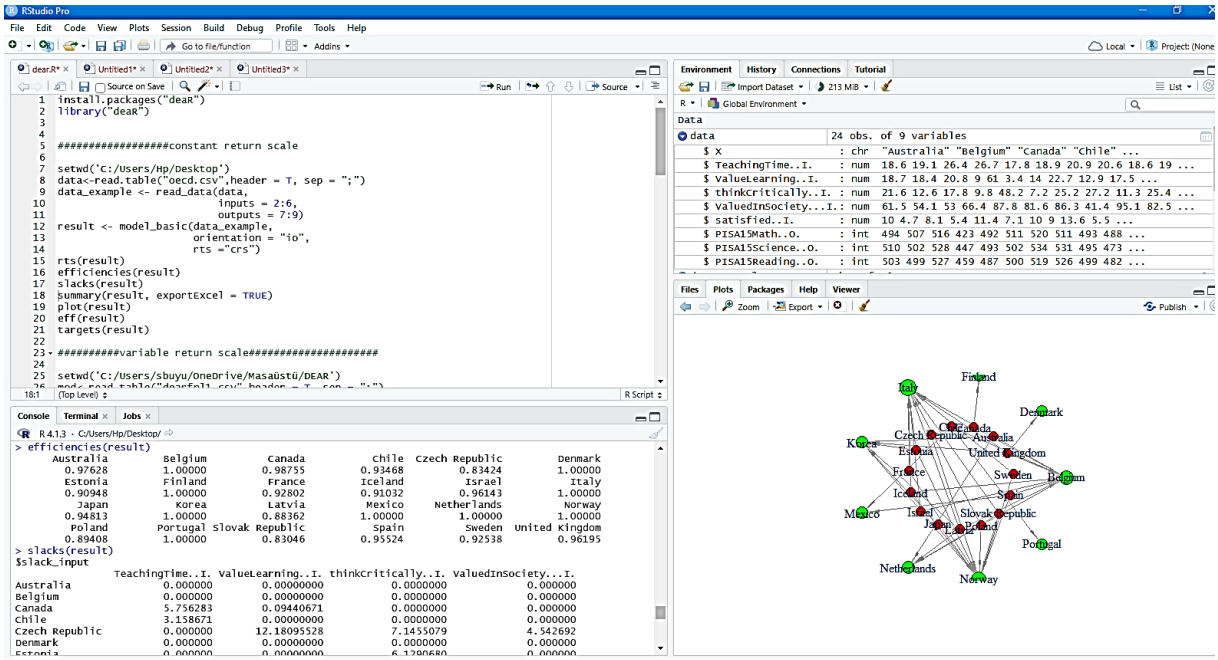


Figure 3. Screenshot for DEA in R Software

Results

In this section, data envelopment analysis findings according to CCR and BCC input-oriented model based on EMS 1.3 DEAP-XP 2.1 and R-4.1.3 software were given, when "teaching time per week (hours), teachers who don't believe they can help their students to value learning (%), teachers who don't believe they can help their students to think critically (%), teachers who don't believe that the teaching profession is valued in society (%), teachers who are not satisfied with their job (%)" variables were taken as input variables and PISA 2015 Math PISA 2015 Science and PISA 2015 Reading literacy variables were taken as output variables. The efficiency ratings of 24 countries were looked at in Table 2.

When the efficiency analysis findings for 24 DMUs were examined according to OECD data, countries with 1/1.000 and 100.00% efficiency points were considered efficient countries in Table 2. The findings obtained from all three software were given in the output format of the software. Belgium, Denmark, Finland, Italy, Korea, Mexico, Netherlands, Norway, and Portugal were found to be effective countries according to the CCR model, when EMS 1.3, DEAP-XP 2.1and R-4.1.3 software were used. Belgium, Canada, Denmark, Estonia, Finland, Italy, Japan, Korea, Mexico, Netherlands, Norway, and Portugal were effective countries according to the BCC model, when EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software were used. In Figure 4, the number of effective and ineffective countries and the efficient distribution of ineffective countries were given by CCR Model when using EMS 1.3, DEAP-XP 2.1, and R-4.0.

Table 2. Efficiency rates of 24 countries by three different softwares

Number	DMUs	CCR (EMS)	CCR (DEAP)	CCR (R)	BCC (EMS)	BCC (DEAP)	BCC (R)	Scale (DEAP)
1	Australia	97.63%	0.976	0.97628	98.29%	0.983	0.98285	0.993
2	Belgium	100.00%	1.000	1	100.00%	1.000	1	1.000
3	Canada	98.75%	0.988	0.98755	100.00%	1.000	1	0.988
4	Chile	93.47%	0.935	0.93468	93.73%	0.937	0.9373	0.997
5	Czech Republic	83.42%	0.834	0.83424	84.27%	0.843	0.8427	0.990
6	Denmark	100.00%	1.000	1	100.00%	1.000	1	1.000
7	Estonia	90.95%	0.909	0.90948	100.00%	1.000	1	0.909
8	Finland	100.00%	1.000	1	100.00%	1.000	1	1.000
9	France	92.80%	0.928	0.92802	96.55%	0.966	0.96551	0.961
10	Iceland	91.03%	0.910	0.91032	91.60%	0.916	0.916	0.994
11	Israel	96.14%	0.961	0.96143	99.49%	0.995	0.99486	0.966
12	Italy	100.00%	1.000	1	100.00%	1.000	1	1.000
13	Japan	94.81%	0.948	0.94813	100.00%	1.000	1	0.948
14	Korea	100.00%	1.000	1	100.00%	1.000	1	1.000
15	Latvia	88.36%	0.884	0.88362	89.81%	0.898	0.89806	0.984
16	Mexico	100.00%	1.000	1	100.00%	1.000	1	1.000
17	Netherlands	100.00%	1.000	1	100.00%	1.000	1	1.000
18	Norway	100.00%	1.000	1	100.00%	1.000	1	1.000
19	Poland	89.41%	0.894	0.89408	91.08%	0.911	0.91081	0.982
20	Portugal	100.00%	1.000	1	100.00%	1.000	1	1.000
21	Slovak Republic	83.05%	0.830	0.83046	86.30%	0.863	0.86298	0.962
22	Spain	95.52%	0.955	0.95524	95.67%	0.957	0.95671	0.998
23	Sweden	92.54%	0.925	0.92538	93.15%	0.932	0.93153	0.993
24	United Kingdom	96.19%	0.962	0.96195	96.56%	0.966	0.96557	0.996

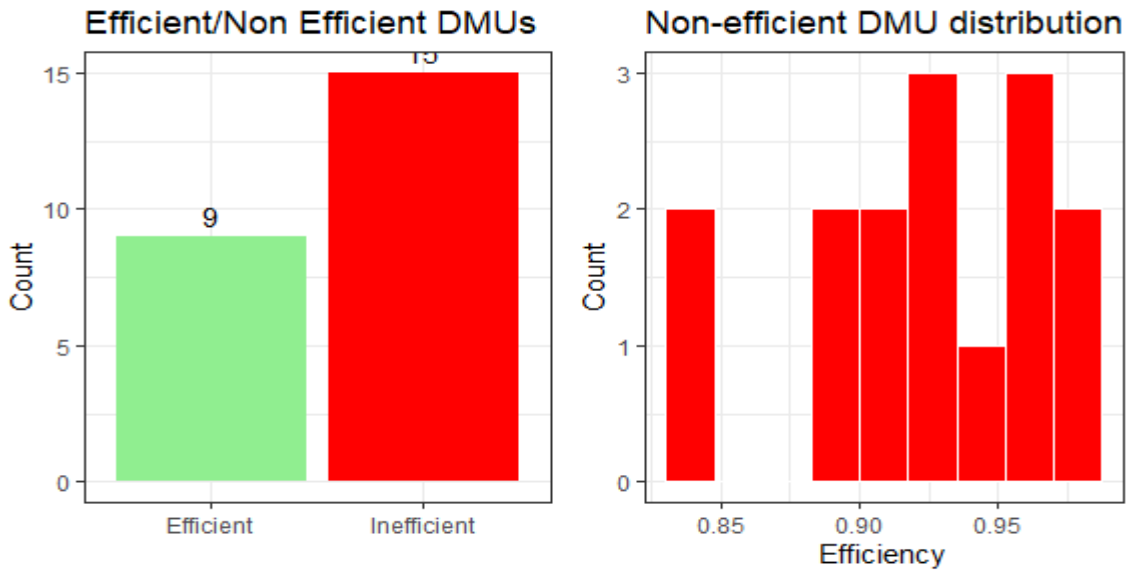


Figure 4. Number of efficient and ineffective countries and efficiency distributions of ineffective countries by CCR model

When Figure 4 was examined, it was seen that 9 countries were efficient, and 15 countries were not efficient according to the CCR model. Looking at the distribution of the efficiency of the ineffective countries, it was seen that 2 countries had an efficiency score of less than 0.85. The number of ineffective countries with an efficiency rate higher than 0.95 was five. According to the CCR model, the country with an efficiency score below 85% was the Czech Republic with an efficiency score of 83.42%.

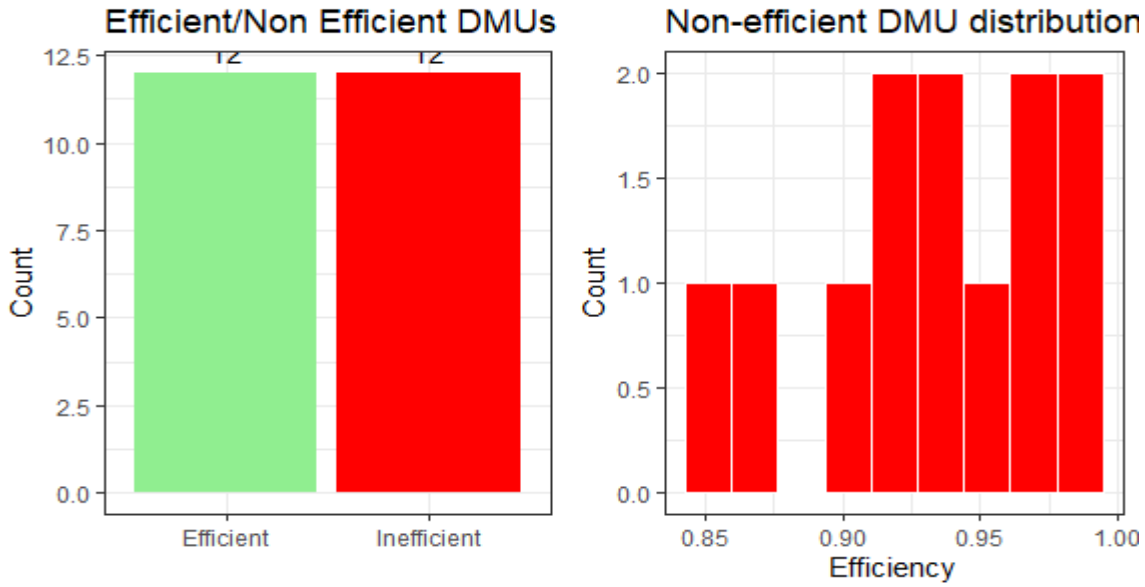


Figure 5. Number of efficient and ineffective countries and efficiency distributions of ineffective countries by BCC model

When Figure 5 was examined, it was seen that 12 countries were efficient, and 12 countries were not efficient according to the BCC model. When the distribution of the efficiency of the ineffective countries was examined, it was seen that one country had an efficiency score less than 0.85. The number of ineffective countries with efficiency rates higher than 0.95 was five. The Czech Republic had an efficiency score of 84.27 percent, which, according to the CCR model, was the country with the lowest efficiency score. The efficiency scores for EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software was identical according to the CCR and BCC models. When the efficiency scores of the CCR and BCC models were compared, it was seen that the average efficiency scores obtained from the BCC model were higher than the CCR model.

Table 3 listed the benchmarks obtained with the CCR and BCC models run with the program's EMS 1.3, DEAP-XP 2.1, and R-4.1.3.

Table 3. Benchmarks by CCR and BCC Models in all three softwares

Number	DMUs	CCR Benchmarks			BCC Benchmarks		
		(EMS)	(DEAP)	(R-4.1.3)	(EMS)	(DEAP)	(R-4.1.3)
1	Australia	2 (0.09) 12 (0.32) 14 (0.35) 17 (0.26)	14(0.346) 17(0.257) 2(0.090) 12(0.323)	2 (0.0903) 12 (0.3226) 14 (0.3459) 17 (0.2573)	6 (0.33) 7 (0.03) 8 (0.03) 14 (0.26) 17 (0.35)	6(0.325) 14(0.258) 8(0.027) 17(0.354) 7(0.035)	6 (0.3252) 7 (0.0347) 8 (0.0273) 14 (0.2583) 17 (0.3545)
2	Belgium	9	9	9	6	6	6
3	Canada	2 (0.73) 8 (0.31)	8(0.307) 2(0.733)	2 (0.7326) 8 (0.3069)	0		0
4	Chile	2 (0.16) 16 (0.58) 20 (0.27)	16(0.577) 2(0.160) 20(0.271)	2 (0.1601) 16 (0.5772) 20 (0.271)	2 (0.18) 6 (0.07) 16 (0.52) 20 (0.23)	6(0.073) 2(0.176) 16(0.524) 20(0.226)	2 (0.1762) 6 (0.0734) 16 (0.5243) 20 (0.2262)
5	Czech Republic	18 (0.99)	18(0.990)	18 (0.99)	18 (1.00)	18(1.000)	18 (1.00)
6	Denmark	1	1	1	6	6	6
7	Estonia	12 (0.72) 14 (0.28)	14(0.277) 18(0.091)	12 (0.7188) 14 (0.2771)	1		1
8	Finland	18 (0.09) 1	12(0.719) 1	18 (0.091) 1	2	2	2
9	France	12 (0.84) 18 (0.19)	12(0.836) 18(0.186)	12 (0.8362) 18 (0.1863)	6 (0.64) 12 (0.20)	18(0.158) 6(0.639)	6 (0.6385) 12 (0.2035)

					18 (0.16)	12(0.204)	18 (0.1579)
		2 (0.43)	2(0.426)	2 (0.4262)	2 (0.13)	18(0.270)	2 (0.1304)
10	Iceland	12 (0.39)	12(0.388)	12 (0.3877)	12 (0.51)	16(0.091)	12 (0.5081)
		18 (0.16)	18(0.163)	18 (0.1632)	16 (0.09)	2(0.130)	16 (0.091)
					18 (0.27)	12(0.508)	18 (0.2705)
		2 (0.50)	14(0.058)	2 (0.5027)	2 (0.52)	14(0.060)	2 (0.5202)
11	Israel	12 (0.36)	2(0.503)	12 (0.3556)	12 (0.37)	2(0.520)	12 (0.368)
		14 (0.06)	18(0.050)	14 (0.0577)	14 (0.06)	18(0.052)	14 (0.0597)
		18 (0.05)	12(0.356)	18 (0.0504)	18 (0.05)	12(0.368)	18 (0.0522)
12	Italy	10	10	10	8	8	8
13	Japan	14 (0.18)	18(0.897)	14 (0.1771)	0	0	0
		18 (0.90)	14(0.177)	18 (0.8968)			
14	Korea	6	6	6	4	4	4
		2 (0.07)	2(0.071)	2 (0.0712)	2 (0.07)	14(0.017)	2 (0.0724)
15	Latvia	12 (0.37)	14(0.017)	12 (0.3727)	12 (0.38)	17(0.532)	12 (0.3787)
		14 (0.02)	27(0.523)	14 (0.0165)	14 (0.02)	2(0.072)	14 (0.0168)
		17 (0.52)	12(0.373)	17 (0.5235)	17 (0.53)	12(0.379)	17 (0.532)
16	Mexico	2	2	2	3	3	3
17	Netherlands	4	4	4	5	5	5
18	Norway	10	10	10	8	8	8
		2 (0.02)	2(0.021)	2 (0.0212)	6 (0.44)	12(0.004)	6 (0.4364)
19	Poland	12 (0.35)	12(0.352)	12 (0.352)	12 (0.00)	17(0.121)	12 (0.0043)
		17 (0.29)	17(0.292)	17 (0.2924)	17 (0.12)	18(0.439)	17 (0.1207)
		18 (0.35)	18(0.346)	18 (0.3462)	18 (0.44)	6(0.436)	18 (0.4386)
20	Portugal	1	1	1	1	1	1
21	Slovak Republic	12 (0.79)	17(0.142)	12 (0.7919)	12 (0.82)	18(0.029)	12 (0.8229)
		17 (0.14)	18(0.028)	17 (0.1422)	17 (0.15)	12(0.823)	17 (0.1477)
		18 (0.03)	12(0.792)	18 (0.0282)	18 (0.03)	17(0.148)	18 (0.0294)
					2 (0.51)	2(0.513)	2 (0.5134)
		2 (0.61)	2(0.611)	2 (0.6106)	12 (0.04)	16(0.078)	12 (0.0388)
22	Spain	16 (0.05)	16(0.048)	16 (0.048)	16 (0.08)	12(0.039)	16 (0.078)
		18 (0.33)	18(0.334)	18 (0.3344)	18 (0.37)	18(0.370)	18 (0.3698)
					6 (0.16)	6(0.162)	6 (0.1618)
23	Sweden	12 (0.51)	12(0.511)	12 (0.5111)	12 (0.33)	18(0.506)	12 (0.3322)
		18 (0.50)	18(0.496)	18 (0.4963)	18 (0.51)	12(0.332)	18 (0.506)
					2 (0.05)	17(0.067)	2 (0.0504)
		2 (0.18)	14(0.342)	2 (0.1761)	6 (0.53)	2(0.050)	6 (0.5258)
24	United Kingdom	6 (0.33)	6(0.332)	6 (0.3321)	8 (0.10)	14(0.255)	8 (0.1022)
		12 (0.16)	12(0.160)	12 (0.1605)	14 (0.25)	8(0.102)	14 (0.2549)
		14 (0.34)	2(0.176)	14 (0.3424)	17 (0.07)	6(0.526)	17 (0.0666)

When Table 3 was examined, it was given how many efficient countries should be referenced, which countries ineffective countries should take as reference, and to what extent. When the benchmarks were examined, Canada was not an effective country according to the CCR model. According to the software EMS, DEAP-XP 2.1 and R-4.1.3, Belgium should be referenced by Canada with the 2nd DMU order at a rate of 0.73 and Finland with the 8th DMU order at a rate of 0.31 when the CCR model was chosen. According to the three software, Canada was the effective country in the BCC model. Canada was not one of the countries that should refer to any country that was not effective according to the three software. The benchmarks in Table 3 show that R-4.1.3, DEAP-XP 2.1, and EMS software gave the same results. The graph of how many times inefficient countries should reference efficient countries was given in Figure 6 for the CCR model and in Figure 7 for the BCC model.

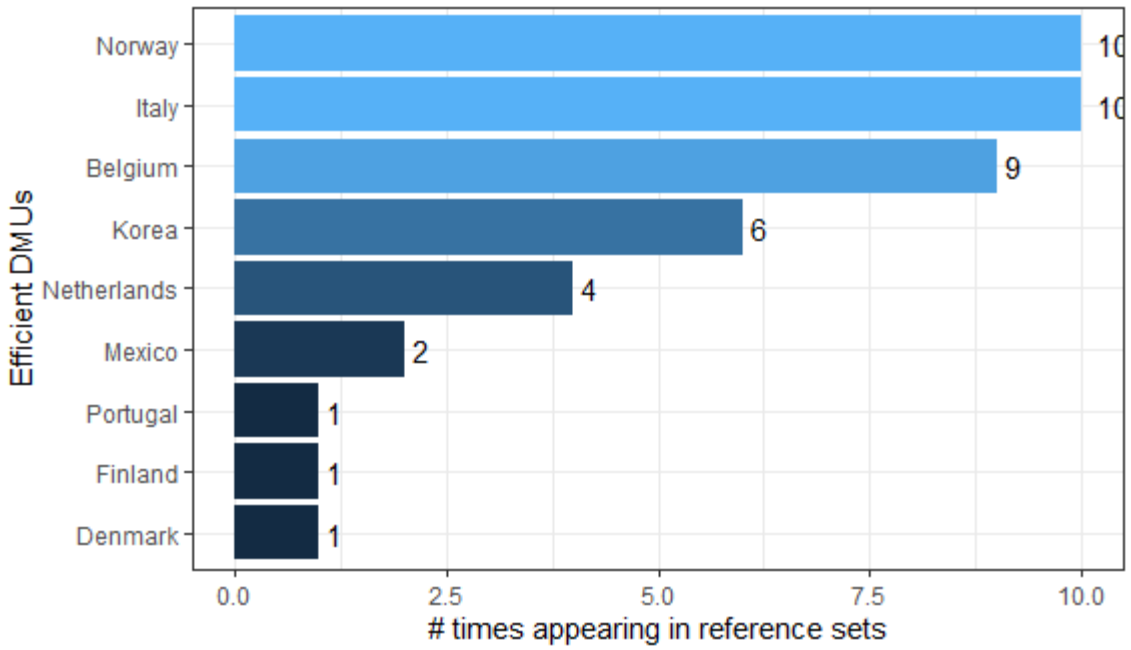


Figure 6. Reference numbers of effective countries by CCR model

When Figure 6 was examined, it was seen that when EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software were used according to the CCR model, Norway and Italy should be taken as references by 10 ineffective countries, and these two countries were the most referenced. Denmark, Finland, and Portugal should only be referenced by one ineffective country.

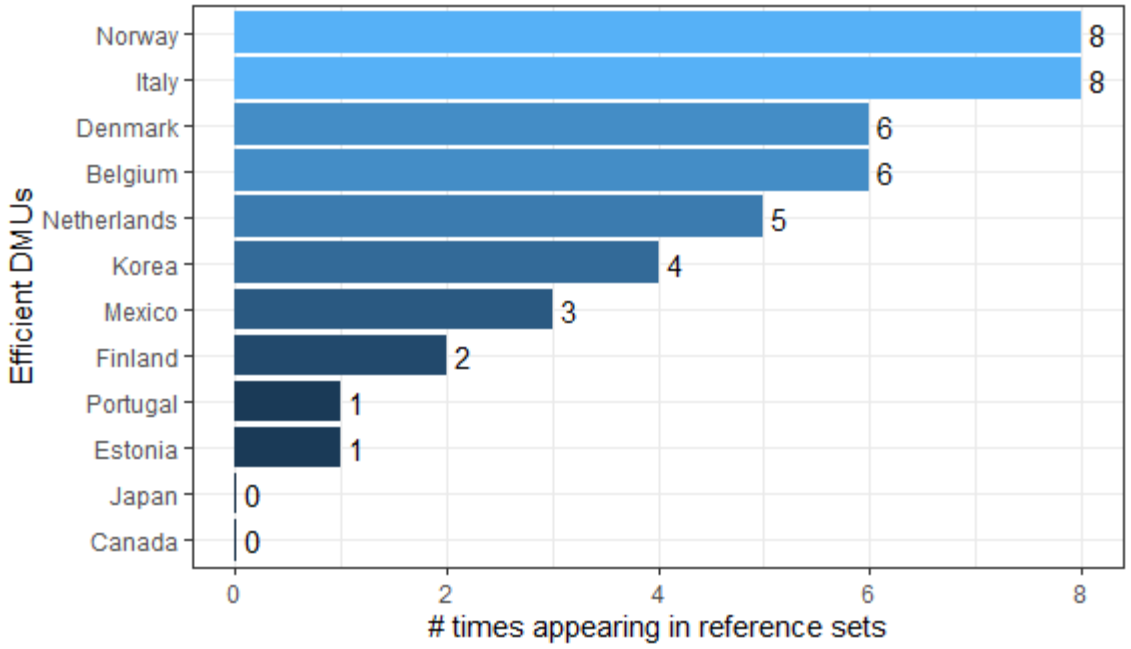


Figure 7. Number of references to effective countries by BCC model

When Figure 7 was examined, it was seen that when EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software were used according to the BCC model, Norway and Italy should be taken as reference by 8 ineffective countries and these two countries were most referenced. Although Japan and Canada were effective countries, they were not referenced by any ineffective countries. EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software produced completely parallel outputs for reference countries and reference quantities. In addition, according to the CCR and BCC models, the reference rate and the number of effective countries may differ partially.

In Figure 8 and Figure 9, Network Diagram for 24 Countries According to the CCR model and the Network Diagram for 24 Countries According to BCC Model were given.

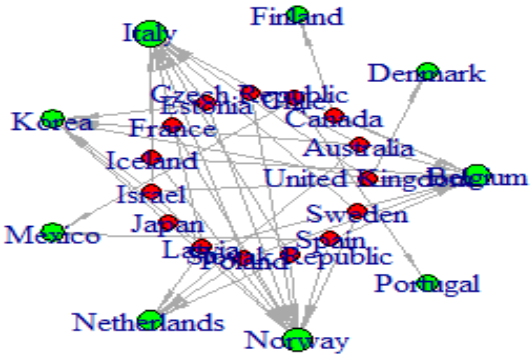


Figure 8. Network diagram for 24 countries according to CCR model

When the diagram in Figure 8 was examined, those shown in green were efficient countries, while those shown in red were inefficient countries. The efficient countries referenced by the inefficient countries were shown with arrows in the diagram. In the diagram, for example, while 10 countries refer to Italy (Australia, Estonia, France, Iceland, Israel, Latvia, Poland, Slovak Republic, Sweeden, United Kingdom), one country (Canada) should take reference Finland.

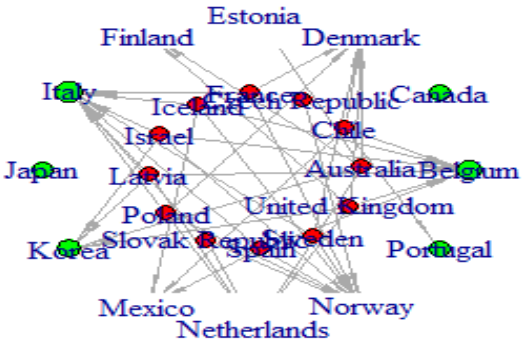


Figure 9. Network diagram for 24 countries according to BCC model

When the diagram in Figure 9 was examined, the countries in the outer part of the diagram were the countries that should be taken as reference, while the countries in the inner part were ineffective. While eight countries should take Italy as a reference (France, Iceland, Israel, Latvia, Poland, Slovak Republic, Spain, and Sweeden), no country should take Canada as a reference.

In Table 4, Table 5, Table 6, Table 7, Table 8, and Table 9, it was seen how much an increase in output could occur if inefficient countries reduce their input values to be efficient. In Table 4, Table 5, Table 6, Table 7, Table 8, and Table 9, it was seen how much an increase in output will occur if inefficient countries reduce their input values to be efficient. When EMS 1.3 software was used for this, the slack values for the CCR model were given in Table 4.

Table 4. Slack values obtained from EMS 1.3 Software for CCR model

Slack Values	Inputs					Outputs		
DMUs	I1	I2	I3	I4	I5	O1	O2	O3
Australia	0	0	0	0	0.53	22.89	0	6.82
Canada	5.76	0.09	0	0	1.79	12.26	2.73	0
Chile	3.16	0	0	0	1.43	27	9.25	0
Czech Republic	0	12.18	7.15	4.54	4.46	4.96	0	20.85
Estonia	0	0	6.13	0	0.89	23.05	0	19.52
France	0	1.01	0	2.16	6.99	10.27	0	2.14
Iceland	0	0	10.32	6.79	0	0	8.73	2.45
Israel	0	0	9.61	0	0	14.65	11.27	0
Japan	0	31.25	43.62	0	7.18	11	0	35.63
Latvia	0	0	0	0	0.49	13.41	0	0.15
Poland	0	4.69	0	0	0	2.75	0.22	0
Slovak Republic	0	0.72	0	0	3.25	0	6.33	17.07
Spain	0	0	0.76	28.74	0	11.01	0	0.52
Sweden	0	0	3.86	8.75	8.12	5.59	0	2.49
United Kingdom	0	0	0	0	8.83	25.05	0	10.79

The interpretation of the slack values in Table 4 was as follows. For example, Australia was an ineffective country according to the CCR model. Australia's reduction of only the fifth input variable "teachers who are not satisfied with their job (%)" by 0.53 unit resulted in a 22.89 unit increase in the first output variable (Mathematics literacy) and a 6.82 unit increase in the third output variable (reading literacy).

Slack values for the CCR model were given in Table 5 when DEAP-XP 2.1 and R-4.1.3 software was used.

Table 5. Slack values obtained from DEAP-XP 2.1 and R-4.1.3 Software for CCR model

Slack Values	Inputs					Outputs		
DMUs	I1	I2	I3	I4	I5	O1	O2	O3
Australia	0.000	0.000	0.000	0.000	0.529	22.895	0.000	6.821
Canada	5.756	0.094	0.000	0.000	1.794	12.258	2.732	0.000
Chile	3.159	0.000	0.000	0.000	1.426	26.997	9.252	0.000
Czech Republic	0.000	12.181	7.146	4.543	4.461	4.960	0.000	20.849
Estonia	0.000	0.000	6.129	0.000	0.893	23.049	0.000	19.517
France	0.000	1.008	0.000	2.156	6.988	10.271	0.000	2.139
Iceland	0.000	0.000	10.323	6.792	0.000	0.000	8.727	2.448
Israel	0.000	0.000	9.606	0.000	0.000	14.649	11.272	0.000
Japan	0.000	31.254	43.622	0.000	7.180	11.004	0.000	35.629
Latvia	0.000	0.000	0.000	0.000	0.493	13.413	0.000	0.152
Poland	0.000	4.690	0.000	0.000	0.000	2.753	0.217	0.000
Slovak Republic	0.000	0.725	0.000	0.000	3.248	0.000	6.334	17.072
Spain	0.000	0.000	0.757	28.742	0.000	11.006	0.000	0.520
Sweden	0.000	0.000	3.859	8.746	8.117	5.585	0.000	2.489
United Kingdom	0.000	0.000	0.000	0.000	8.835	25.053	0.000	10.792

The interpretation of the slack values in Table 5 was as follows. For example, Australia was an ineffective country according to the CCR model. Reducing just Australia's fifth input variable "teachers who are not satisfied with their job (%)" by 0.529 resulted in a 22.895 unit increase in the first output variable (Mathematics literacy) and 6.821 unit increase in the third output variable (Reading literacy).

The slack values for the BCC model were given in Table 6 when using the EMS software.

Table 6. Slack values obtained from EMS 1.3 Software for BCC model

Slack Values	Inputs					Outputs		
DMUs	I1	I2	I3	I4	I5	O1	O2	O3
Australia	0	0	0	0	0.2	21.02	0	3.82
Chile	3.67	0	0	0	1.22	28.99	9.68	0
Czech Republic	0	12.3	7.22	4.59	4.51	10	5	26
France	0	3.21	0	10.95	6.65	12.3	2.09	0
Iceland	0	0	8.98	0.69	0	0	9.42	6.76
Israel	0	0	9.94	0	0	31.5	27.9	16.65
Latvia	0	0	0	0	0.5	21.51	8.01	8.13
Poland	0	7.17	0	1.16	0.18	3.08	0	0
Slovak Republic	0	0.75	0	0	3.38	18.6	24.64	35.48
Spain	0	0	0.29	26.77	0	10.77	0	1.71
Sweden	0	0	3.43	11.11	8.01	5.47	0	1.6
United Kingdom	0	0	0	0	8.65	22.18	0	9.14

The interpretation of the slack values in Table 6 was as follows. For example, Australia was an ineffective country according to the BCC model. Australia's reduction of just the fifth input variable "teachers who are not satisfied with their job (%)" by 0.2 units resulted in 21.02 unit increase in the first output variable (Mathematics literacy) and a 3.82 unit increase in the third output variable (Reading literacy).

When using DEAP-XP 2.1 and R-4.1.3 software, slack values for BCC model were given in Table 7.

Table 7. Slack values obtained from DEAP-XP 2.1 and R-4.1.3 Software for BCC model

Slack Values	Inputs					Outputs		
DMUs	I1	I2	I3	I4	I5	O1	O2	O3
Australia	0.000	0.000	0.000	0.000	0.204	21.025	0.000	3.823
Chile	3.669	0.000	0.000	0.000	1.225	28.995	9.684	0.000
Czech Republic	0.000	12.304	7.218	4.589	4.507	10.000	5.000	26.000
France	0.000	3.214	0.000	10.946	6.652	12.304	2.094	0.000
Iceland	0.000	0.000	8.979	0.688	0.000	0.000	9.421	6.757
Israel	0.000	0.000	9.940	0.000	0.000	31.498	27.899	16.653
Latvia	0.000	0.000	0.000	0.000	0.501	21.507	8.006	8.128
Poland	0.000	7.170	0.000	1.158	0.179	3.083	0.000	0.000
Slovak Republic	0.000	0.753	0.000	0.000	3.376	18.603	24.636	35.481
Spain	0.000	0.000	0.295	26.766	0.000	10.772	0.000	1.708
Sweden	0.000	0.000	3.434	11.109	8.011	5.470	0.000	1.596
United Kingdom	0.000	0.000	0.000	0.000	8.654	22.179	0.000	9.141

The interpretation of the slack values in Table 7 was as follows. For example, Australia was an ineffective country according to the BCC model. Reducing just Australia's fifth input variable "teachers who are not satisfied with their job (%)" by 0.204 unit resulted in a 21.025 unit increase in the first output variable (Mathematics literacy) and 3.823 unit increase in the third output variable (Reading literacy). The slack values obtained from the R-4.1.3 software and the slack values obtained from the EMS 1.3 software and DEAP-XP 2.1 software were the same. More than two digits were obtained after the comma only in R-4.1.3 and DEAP-XP 2.1 software, while in EMS 1.3 software only two digits were given after the comma. In addition, the findings of the slack values obtained from the CCR and BCC models differed partially.

Conclusion

According to this study, the variables are "teachers who don't believe they can help their students to value learning (%)," "teachers who don't believe they can help their students to think critically (%)," and "teachers who don't believe they can help their students to value learning" are related to teachers' self-efficacy. Data envelopment analysis was used to determine the input and output variables for the variables "teachers who don't believe that the teaching profession is valued in society (%)" and "teachers who are not satisfied with their job (%)" related to job satisfaction of teachers among TALIS 2013 indicators and science, reading, and mathematical literacy scores. Efficiency analysis of 24 countries was carried out with three different software.

As a result of the research, according to the CCR model, effective countries were Belgium, Denmark, Finland, Italy, Korea, Mexico, Netherlands, Norway, and Portugal, when EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software were used. According to the CCR model, the number of effective countries was nine, when three software were used. As a result of the research, according to the BCC model, when EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software were used, the effective countries were Belgium, Canada, Denmark, Estonia, Finland, Italy, Japan, Korea, Mexico, Netherlands, Norway, and Portugal. When EMS 1.3, DEAP-XP 2.1, and R-4.1.3 were used, the number of effective countries was twelve, according to the BCC model. Norway and Italy were the countries that should be referenced most by ineffective countries to increase their efficiency scores in EMS 1.3, DEAP-XP 2.1, and R-4.1.3 software. When slack values were examined, R, DEAP-XP 2.1, and EMS 1.3 gave the same results. The results were exactly the same in R-4.1.3, DEAP-XP 2.1, and EMS 1.3 software. Efficiency analysis of 24 countries was conducted when teachers' self-efficacy perception and job satisfaction were taken as input variables and students' mathematics, science, and reading literacy performance in PISA were taken as output variables. As a result of the research, it was found that some countries need to decrease some input variables to increase their efficiency scores. In other words, it was necessary to increase the success scores in PISA 2015 and decrease the percentages of individuals who have negative/reverse coded expressions, especially in the self-efficacy perception and job satisfaction measurements. When the studies in the literature were analyzed, there were studies on positive correlations between job satisfaction and self-efficacy perception (e.g., Ainley & Carstens, 2018; Caprara et al., 2006; Perera & John, 2020; Tschannen-Moran & Hoy, 2001; Tschannen-Moran et al., 1998; Zee & Koomen, 2016). In order to increase the efficiency score of ineffective countries, studies should be carried out to increase positive teacher job satisfaction and self-efficacy perception.

Teachers having a lot of weekly teaching time can cause time problems in the design of the courses and administrative duties. This time constraint affects the quality of teaching (Benner & Partelow, 2017). Effective countries such as Finland have lower teaching time than in other countries (see Paronen & Lappi, 2018). It should not be deduced that if the teaching time is long, the success will be high. The important thing is to conduct the lessons effectively. In this research, Canada and Chile should make improvements in the "Teaching time per week (hours)" input variable in CCR model, only Chile should make improvements according to the BCC model. When the Slack values were examined, the improvements that need to be made and the positive differences in the output variables were exactly the same in all three softwares.

Our lives and our success in life are influenced by the perception of self-efficacy, which Albert Bandura (1977) studied within the context of social cognitive theory. According to an educational study (Egido Gálvez, López-Martín, Manso, & Valle, 2018), one of the most significant factors influencing student motivation and success is how teachers see their talents. Pintrich, Smith, Garcia, and Mckeachie (1993) found that high self-efficacy belief effectively fulfilled tasks successfully. In the study, reverse-coded "teachers who don't believe they can help their students to value learning (%)" and "teachers who don't believe they can help their students to think critically (%)" input variables were discussed. Canada, Czech Republic, France, Japan, Poland, and Slovak Republic should make improvements in terms of "teachers who don't believe they can help their students to value learning (%)" variable. Especially Czech Republic, Estonia, Iceland, Israel, Japan, Spain, and Sweden should make improvements in terms of "teachers who don't believe they can help their students to think critically (%)" input variable. In particular, Japan is the country that needs to make the highest improvement in the second and third input variables (variables related to self-efficacy), and it should increase teachers' self-efficacy beliefs. In addition, when slack values were examined in terms of self-efficacy perception, exactly the same results emerged in all three software.

High job satisfaction among teachers is associated with obtaining high students' achievement. To reveal this relationship, it is important to conduct research by linking the OECD's TALIS and PISA results (Dicke et al., 2020). Sealy, Perry, and DeNicola (2016), in their research with PISA and TALIS data, found that there is a relationship between job satisfaction and student achievement in some countries. Similarly, in this study, data envelopment analysis was carried out based on the finding that as job satisfaction increases, student success increases. Czech Republic, France, Iceland, Poland, Spain, and Sweden should make improvements in terms of the "teachers who don't believe that the teaching profession is valued in society (%)" variable. Australia, Chile, Czech Republic, France, Latvia, Poland, Slovak Republic, Sweden, and United Kingdom should make improvements in terms of the "teachers who are not satisfied with their job (%)" variable.

Luthans (2000) mentioned four ways to increase job satisfaction. The first was to increase job satisfaction, the second was to ensure fair pay, advancement, and benefits, the third was to place people in jobs that suited their skills and interests, and the fourth was to increase job satisfaction by making the job suitable for the individual rather than, as with the third item, finding suitable candidates for the job. According to this concept, underperforming nations can raise their input values by looking at the working conditions for educators.

Variables related to the perception of self-efficacy were discussed in this study. To increase the self-efficacy of teachers, well-equipped and self-aware teachers should be trained.

An important result of the research was that the findings were the same when free R-4.1.3, DEAP-XP 2.1, and EMS 1.3 software were used. Researchers were recommended to analyze the data using the "deaR" package in R-4.1.3 in data envelopment analysis, as shown in figures, tables, and more results. It can be said that DEAP-XP 2.1 software was more complex for analysis by taking companies or firms as DMUs with the logic of efficiency of businesses. When using DEAP-XP 2.1 software, researchers should display decimal numbers with dots instead of commas in the input file. Otherwise, the software gives erroneous results. EMS 1.3 software, on the other hand, has a user-friendly interface but does not allow graphics and figures. R-4.1.3 software, on the other hand, not only analyzes data for old methods such as VRS and CRS, but also analyzes data by considering many models such as Fuzzy DEA, Non-radial DEA model, and the situation such as dealing with undesirable outputs in DEA. Finally, R-4.1.3 gave more information, figures, and output, followed by DEAP XP-2.1 and EMS 1.3 software, respectively.

Recommendations

The findings from the CCR model based on the constant return assumption and the BCC model based on the variable return assumption differed partially in this research. When educational research was examined, some studies use both and only one. It is recommended that which model is used in data envelopment analysis and whether this model is input or output oriented should be reported in research. Researchers were advised to specify which software they were analyzing the data within their research.

There are several limitations to this study. Five inputs, three outputs, and 24 DMUs were utilized for the research. Various input variables can be used to illustrate the link between TALIS and PISA. Data envelopment analysis, a nonparametric method, was used in this work to evaluate the data. Research can be conducted by combining TALIS and PISA data using different parametric methods. Different countries were considered as DMUs in this research. For example, data envelopment analysis can be done by working with country data and considering regions or school types as DMUs. To consider more input and output numbers, it is necessary to increase the number of DMUs. By increasing the number of DMUs and increasing the number of inputs and outputs, similar studies can be carried out with advanced data envelopment analysis techniques.

Acknowledgments or Notes

There is no conflict of interest to disclose.

Author(s) Contribution Rate

SB wrote all sections including “abstract, introduction, method, findings, conclusion”. SB had roles in the conceptualization, resources, data analysis, reporting, drafting, reviewing and editing.

Conflicts of Interest

There is no conflict of interest.

Ethical Approval

Ethical approval is not required. Because data from OECD was used in this research.

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Examining the Relationships between the Burnout Levels and Creative Thinking Levels of Special Education Teachers

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Examining the Relationships between the Burnout Levels and Creative Thinking Levels of Special Education Teachers

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Abstract

In this study, the relationships between the burnout and creative thinking levels of special education teachers (SET) were examined. 214 special education teachers were contacted to accomplish this goal. The Maslach Burnout Inventory-Educator's Survey and the Marmara Creative Thinking Tendency Scale were used in the study. Conducted in accordance with the goal, the surveys revealed that the creative thinking tendencies of SETs decrease as their burnout levels increase; their creative thinking, self-discipline, novelty-seeking, courage, curiosity, and flexibility levels decrease as their emotional exhaustion levels increase; and their creative thinking, self-discipline, novelty-seeking, courage, curiosity, doubt, and flexibility levels increase as their personal accomplishment levels increase. In conclusion, improving the salaries, providing training on scientific-based practices, and organizing in-service training were suggested in the study in order to reduce the burnout of SETs and increase their creative thinking tendencies.

Keywords: Special education teachers, Creative thinking, Occupational burnout.

Introduction

Seeing creativity as a cognitive and logical phenomenon, researchers explain the concept as an individual using his or her mind and intelligence in an original and productive way (Aslan, 2001). In this approach, creativity is a kind of thinking, reasoning, conceptualizing, and problem-solving activity. A creative thinking process, on the other hand, is emphasized as some processes going on in the subconscious during the pause before an individual suddenly reaches the solution in his/her mind (Aslan, 2001). Creative thinking, in particular, can be defined as thinking in an original, fluent, logical, extremely flexible, and unusual manner (Sönmez, 2017). Thus, it can be said that an individual can overcome the negative situations s/he encounters in both his/her professional and private life through creative thinking.

When it comes to professional life, we come across the concept of occupational burnout. Occupational burnout is generally seen in people who are idealistic and highly motivated. Under emotional pressure for a long time, these people with high expectations may face stress, anxiety, and depression. Therefore, it is crucial to define the concept of burnout, which is frequently encountered in professional life (Pines, 2003). This concept is thought to be related to the expansion of the boundaries of people's professional lives and the increase in boredom (Gönültaş, 2017). According to Maslach, burnout is a syndrome that occurs as emotional exhaustion, depersonalization, and reduced personal achievement in people who interact with others a lot (Maslach, 1982; Maslach & Jackson, 1981). As can be understood from the explanations, burnout is seen in almost all occupational groups that interact with people intensely due to the nature of their work, especially in the health and education sectors (Kaya, 2008). When it comes to education, the rate is reported to be quite high among school administrators and general and special education teachers (SET) working in this field (Emery & Vanderberg, 2010; Fernet et al., 2012; Girgin & Baysan, 2005; Kuşçu, 2020; Nichols & Sosnowsky, 2002; Oplatka, 2002; Talmor, Reiter & Feigin, 2005; Westman & Etzion, 1999; Zabel & Zabel, 2002). As stated in the literature, SETs are among the groups in education that experience occupational burnout. Studies exhibit SETs as the group that is more prone to having occupational burnout than their colleagues in other groups are (Girgin & Baysan, 2005; Kocaman, 2018), or have higher burnout levels than others (Beck & Gargulia, 1986; Kocaman, 2018; Kuşçu, 2020).

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SET is the person referred to as "specially trained personnel" in the definition of special education. These teachers provide education in accordance with the needs and characteristics of individuals with special needs, as included in the definition of special education. Therefore, it is reported in the literature that SETs have different direct and indirect roles and have many different responsibilities such as special education counseling, teaching, preparing individualized education programs (IEP), preparing RR (resource room) programs, making evaluations, and cooperating (Güven, 2021a). According to studies, this level of responsibility causes stress (Kocaman, 2018; Kuşçu, 2020; Robinson, Bridges, Rollins, & Schumacker, 2019), and all of these negative situations lead to burnout (Aslan & Aslan, 2014; Brunsting, Sreckovic, & Lane, 2014; Dere Çiftçi, 2015; Girgin & Baysan, 2005; Karahan & Balat, 2011; Wisniewski & Gargiolu, 1997).

When the studies in Turkey are examined, it is seen that different dimensions of burnout in SETs were looked into and different results were obtained (Artıran, Er, & Artıran, 2019; Aslan & Aslan, 2014; Gönüldaş, 2017; Karacan, 2012; Karahan & Uyanık Balat, 2011; Kocaman, 2018; Saraç, 2018; Şahin & Şahin, 2012). In their study on the relationship of SETs' negative thoughts with burnout and job satisfaction, Artıran, Er, & Artıran (2019) reported that negative automatic thoughts of teachers increase the level of burnout and decrease job satisfaction. Kocaman (2018) examined the relationship between the burnout levels and the classroom management skills of teachers working in special education schools but did not find a significant relationship. However, Saraç (2018) researched the burnout levels of teachers working in special education; and concluded that teachers in this field who are married, do not find the profession suitable for themselves, and did not choose this profession voluntarily experience emotional burnout more. Gönüldaş (2017) conducted a study on the self-efficacy perceptions, levels of anxiety, and burnout that special education teacher candidates and teachers have and concluded that the teachers' anxiety and burnout decrease as their competencies increase.

There are many foreign studies on SETs' burnout looked into through different dimensions (Emey & Vanderberg, 2010; Fore, Martin & Bender, 2002; Langher, Caputo & Ricci 2017; Ugwoke, 2018). Robinson et al. (2019) assessed the relationship between SETs' burnout and job satisfaction. The results revealed that burnout increases as job satisfaction decreases. Al-Bawaliz, Arbeyat and Hammadneh (2015) examined the relationship between emotional intelligence and burnout of SETs in Jordan, and the results showed that burnout decreases as emotional intelligence increases. Batained and Alsagheer (2012) analyzed the relationship between SETs' social support and burnout in the United Arab Emirates, and the results reported that the social support provided to teachers by their environment reduces burnout. Lavian (2012) researched the effect of school climate on burnout among teachers who teach at home and SETs in Israel. As a result, it was revealed that the non-supportive school climate causes teachers' burnout to increase. Platsidou (2010) examined the relationship between emotional intelligence, burnout, and job satisfaction in Greek SETs. It is understood that the burnout of teachers with high emotional intelligence is low and their job satisfaction is high. When all the studies are scanned in general, it is seen that different dimensions of SETs' burnout were examined via different variables, but the relationship between creative thinking and occupational burnout has not been examined yet.

Aim of the Study

This study aims to look into the relationships between occupational burnout and creative thinking levels of SETs. The subgoals of the study are as follows:

1. Is there a significant relationship between the occupational burnout levels of special education teachers and their creative thinking tendencies?
2. Do the occupational burnout levels of special education teachers predict their creative thinking tendencies?

Method

Research Design

This study was carried out according to the relational screening model, as it aimed to examine the relationships between the creative thinking levels and occupational burnout of SETs. This model is a screening approach that targets determining the existence of covariation between two or more variables. In the relational screening model, it is tried to see whether the variables change together and how it happens if there is a change (Karasar, 2011).

Participants

The study group consists of SETs working all around Turkey. Table 1 provides information about the SETs' seniority, department of graduation, seniority, age, gender, marital status, level of education, and age.

Table 1. Demographic information of the teachers

		N	*%*
Gender	Female	146	68.2
	Male	68	31.8
Marital Status	Single	95	44.3
	Married	119	55.7
Age	20-25	37	17.3
	26-30	66	30.9
	31-35	50	23.4
	36-40	35	16.3
	41 and older	26	12.1
Education Level	Associate Degree	17	8
	Bachelor's Degree	179	83.6
	Master's Degree	18	8.4
Department Graduated from	Special Education and Related to Special Education	128	59.8
	Departments Other than Special Education (preschool, child development, classroom teaching, etc.)	86	40.2
Type of the Institution S/He Works at	Rehabilitation Center	44	20.6
	Primary School Special Education Classroom, Resource Room	65	30.4
	Special Education Implementation School	53	24.8
	Special Education Kindergarten	14	6.5
	Special Education Implementation Center and/or Special Education Kindergarten	24	11.2
	Other Institutions	14	6.5
Special Education Group Type S/He Works with	Intellectual Disability	100	47.2
	Autism Spectrum Disorder	61	28.91
	Special Learning Disability	15	7
	Developmental Delay	2	0.09
	Other Special Education Groups	36	16.8
Seniority	1-5	102	47.7
	6-10	71	33.2
	11-15	21	9.8
	16-20	16	7.4
	21 and more	4	1.9

Of the teachers, 146 (68.2%) are female, 68 (31.8%) are male; 95 (44.3%) are single and 119 (55.7%) are married. In terms of age, 37 (17.3%) are 20-25 years old, 66 (30.9%) are 26-30 years old, 50 (23.4%) are 31-35 years old, 35 (16.3%) are 36-40 years old, and 26 (12.1%) are 41 years old and older. 17 (8%) of the teachers have an associate degree, 179 (83.6%) have a bachelor's degree, and 18 (8.4%) have a master's degree. In terms of the department graduated, 128 teachers (59.8%) graduated from special education and special education-related fields, while 86 (40.2%) graduated from departments other than special education such as preschool, child development, classroom teaching, physics, sociology, journalism, and archeology. In terms of the institution they work at, 44 (20.6%) work at a rehabilitation center, 65 (30.4%) work at a primary school special education classroom, resource room, 53 (24.8%) work at a special education implementation school, 14 (6.5%) work at a special education kindergarten, 24 (11.2%) work at a special education implementation center and/or special education kindergarten, and 14 (6.5%) work at other institutions. In terms of special education group type they currently work with, 100 (47.2%) work with the groups with intellectual disability, 61 (28.91%) work with the groups with autism spectrum disorder, 15 (7%) work with the groups with a special learning disability, 2 (.09%) work with the groups with developmental delay, and 36 (16.8%) work with other special education groups. In terms of seniority, 102 (47.7%) have 1-5 years, 71 (33.2%) have 6-10 years, 21 (9.8%) have 11-15 years, 16 (7.4%) have 16-20 years, and 4 (1.9%) have 21 years or more.

Data Collection Tools

Three different data collection tools were used in this study. The first one is the demographic data form developed by the researchers. On this form, questions on the teachers' age, gender, marital status, educational level, departments from which they graduated, the special education group type they interact with, and their period of special education work are all asked.

The second one is the *Maslach Burnout Inventory-Educator's Survey*. This form was utilized to determine the burnout levels of SETs. To calculate the reliability of the MBI-ES within the scope of the study, the internal consistency coefficient was calculated for each subscale, as in the original. As a result of the analyses, the Cronbach's alpha coefficients for the emotional exhaustion, depersonalization, and personal achievement subscales were found to be.83, .63, and.80, respectively. In the analysis of validity, Ergin (1992) stated that in the scale's adaptation study conducted with healthcare professionals, the seven-point rating format is not suitable for Turkish culture and rating with "never, rarely, sometimes, often, always" is more useful. Developed by Maslach and Jackson (1981), Maslach Burnout Inventory-Educator's Survey was adapted into Turkish by İnce and Şahin (2015). This scale consists of 22 items and three subdimensions. The 1st, 2nd, 3rd, 6th, 8th, 13th, 14th, 16th, and 20th items include the "Emotional Exhaustion" subdimension; the 5th, 10th, 11th, 15th, and 22nd items include the "Depersonalization" subdimension , and the 4th, 7th, 9th, 12th, 17th, 18th, 19th, and 21st items include the "Personal Achievement" subdimension. For scoring, the items in the emotional exhaustion and depersonalization subdimensions are scored in the same way, and the items in the personal achievement subdimension are scored inversely. While some researchers in this field argue that three separate scores should be calculated for each individual (Çam, 1999), other researchers state that the total burnout score can be obtained by adding the scores from the items constituting the subdimensions of burnout together (Cordes & Dougherty, 1993). In this study, the total burnout scores were calculated, as well as the subdimension scores. The 5-point Likert scale in the Maslach Burnout Inventory-Educator's Survey is as follows: "Never (1)", "Very Rarely (2)", "Sometimes (3)", "Mostly (4)", "Always (5)".

Lastly, the *Marmara Creative Thinking Tendency Scale* was employed. This scale was used to examine the creativity levels of SETs. The validity and reliability of this scale, which was developed by Özgenel and Çetin (2017), was conducted with 410 teachers working in the district of Pendik, Istanbul. The Cronbach's alpha internal consistency coefficient calculated for the entire scale was found to be 0.87. The accuracy of the structure consisting of 25 items and 6 factors obtained as a result of the analyses was proven via factor analysis. The factor and item distributions determined as a result of the validity and reliability are as follows: "Self-discipline: 1, 6, 7, 15, 23", "Novelty-Seeking: 2, 5, 8, 12, 17, 19, 22, 24", "Courage: 9, 11, 14, 25", "Curiosity: 3, 10, 21", "Doubt: 4, 16", and "Flexibility: 13, 18, 20". The options in the Marmara Creative Thinking Tendency Scale, which is a Likert-type scale, consist of the answers "never, rarely, sometimes, usually, and always". In this study, reliability analysis was performed for the entire scale, and Cronbach's alpha internal consistency coefficient was achieved at 0.89.

Data Collection Process

Ethics committee approval for the study was obtained from Istanbul Sabahattin Zaim University. The data related to this study was collected through Google Forms. The study group was informed about the purpose of the study and the protection of personal information, etc., and consent was obtained for voluntary participation in the study. The data collection process took approximately 3 months.

Data Analysis

The normality and internal consistency coefficient values for the two scales used in the study are displayed in Table 2. The scores obtained from the Thinking Tendency and Burnout Scales were seen to be distributed normally. Additionally, it appears that the two scales' internal consistency coefficients are at an acceptable level.

Table 2. The burnout and creative thinking tendency scales' kurtosis, skewness, and reliability values

	N	*M*	*sd*	Skewness	Kurtosis	Cronbach a
Burnout	214	46.915	11.861	.325	-.417	.713
Creative Thinking Tendency	214	103.247	10.666	-.085	-.455	.916

From Table 2, it was seen that the kurtosis and skewness values of the data collected from the scales are between -1 and +1, and it was decided that the data has a normal distribution. The data were analyzed using correlation and simple regression analyses based on the normal distribution findings.

Findings

The correlation findings between the variables are given in Table 3.

Table 3. The findings of a correlation study between SETs' creative thinking tendencies and professional burnout levels

		Burnout
Self-Discipline	r	-.559**
	p	.000
	N	214
Novelty-seeking	r	-.439**
	p	.000
	N	214
Courage	r	-.390**
	p	.000
	N	214
Curiosity	r	-.383**
	p	.000
	N	214
Doubt	r	-.181**
	p	.008
	N	214
Flexibility	r	-.351**
	p	.000
	N	214
Creative thinking (total)	r	-.510**
	p	.000
	N	214

Table 3 displays the findings of the correlation analysis conducted to identify the association between special education teachers' levels of burnout and their tendencies to creative thinking. Burnout and self-control, novelty seeking, courage, curiosity, and flexibility variables were shown to have a moderately negative link, and doubt and burnout were found to have a weakly negative correlation. Table 4 displays the findings of the basic regression analysis that was carried to see if the burnout levels of special education teachers predicted their tendency to creative thinking.

Table 4. The Results of the Simple Regression Analysis Regarding Whether Special Education Teachers' Burnout Levels Predict Their Creative Thinking Tendencies

Independent Variable	Dependent Variable	B	Std. Error	(β)	t	*p*	R	r^2	F	*p*
Burnout	Self-discipline	-.123	.013	-.559	-9.813	.000	.559	**.312**	96.285	.000
	Novelty-seeking	-.142	.020	-.439	-7.109	.000	.439	**.192**	50.534	.000
	Courage	-.083	.014	-.390	-6.169	.000	.390	**.152**	38.062	.000
	Curiosity	-.048	.008	-.383	-6.032	.000	.383	**.146**	36.381	.00
	Doubt	-.018	.007	-.181	-2.686	.008	.181	**.033**	7.214	.008
	Flexibility	-.045	.008	-.351	-5.462	.000	.351	**.123**	29.832	.000
	Creative thinking (total)	-.459	.053	-.510	-8.639	.000	.510	**.260**	74.626	.000

According to the results of the simple regression analysis, the burnout levels of special education teachers were significantly negatively predicted (β=-.510, p<.01) by their creative thinking tendencies. The total score of special education teachers' creative thinking tendencies explains 26% of the variance observed in relation to their burnout

level scores. Among the variables related to creative thinking, it was observed that the self-discipline dimension (β= -0.123; p<.01) has the highest, negative, and significant effect for the burnout variable, while the doubt dimension (β= -0.181; p<.01) has the lowest, negative, and significant effect for the burnout variable.

Discussion

Under this heading, the findings are discussed in detail. The study findings revealed that there is a negative relationship between SETs' occupational burnout and creative thinking. According to this result, it can be said that SETs' creative thinking levels decrease as their occupational burnout levels increase, and their creative thinking levels increase as their occupational burnout levels decrease. Within the scope of the study, occupational burnout can be mentioned as a risk factor for creative thinking. When the literature on the subject is examined, similar results are seen to have been reached. In general, researchers in the field of education report that positive school climate influences creative thinking (De Calvalho, 2014; Hillel Lavien, 2012; Luecke, 2021) and they state that school climate meaningfully influences teachers' creative thinking levels (Türkoğlu & Özgenel, 2021). Similarly, Doğan (2015) emphasized that the creative thinking tendencies of individuals increase as long as the environmental conditions are suitable. In addition, Memduhoğlu, Uçar and Uçar (2017) stated that working in collaboration is one of the elements that encourage individuals to think creatively. On the other hand, studies on the relationships between SETs' burnout and job satisfaction reveal that burnout decreases as job satisfaction increases (Artıran, Er, & Artıran, 2019; Emery & Vanderberg, 2010; Platsidaou, 2010; Platsidaou & Agaliotis, 2008; Robinson et al., 2019). In their study, Hillel Lavien (2003) also reached similar results. Studies show that as long as the school climate of SETs is positive (Hillel Lavien, 2012) and teamwork and cooperation, which are the essential conditions of special education, are at work (Güven, 2021b), the burnout of SETs will decrease, and this will contribute to their creative thinking processes. When evaluated in general, this study's findings are in parallel with similar studies in the literature.

According to the study findings, it was determined that as the emotional exhaustion levels of SETs increase, there is a decrease in the levels of self-discipline, novelty-seeking, courage, curiosity, and flexibility, which are included in the scope of creative thinking characteristics. The results of the studies on the subject in the literature are in parallel with the results of this study. For instance, in the study by Alvinia and Pashazadeh (2018), a positive relationship was found between teachers' motivation and self-efficacy and creativity, while a negative relationship was found between burnout and creativity. Moreover, researchers report that emotional exhaustion causes depression in individuals and can lead to having low self-perception and negative feelings towards themselves (Alvinia & Pashazadeh, 2018; Awa, Paulmann & Walter, 2010). When we look at the results of all this research and the nature of creative thinking, it is once again understood that people are undesirably affected by their negative self-perception and their emotions toward themselves. In addition to the mentioned findings, researchers state that lack of self-confidence, low self-perception, behaviors to cope with negative situations, indiscipline, resistance to new thoughts, and lack of motivation negatively affect creative thinking (Doğan, 2015; Kunter & Holzberger, 2014; Memduhoğlu, Uçar & Uçar, 2017) and this can increase burnout in a person (Alvinia & Pashazadeh, 2018; Awa, Paulmann & Walter, 2010). Here, it can be said that SETs' creative thinking features should be increased to prevent them from reaching emotional exhaustion levels. Reducing SETs' emotional exhaustion and increasing their creativity also means increasing their quality of life and enabling their motivation to be sustainable. In sum, motivation can be said to be one of the biggest factors in increasing teachers' creative thinking and decreasing their emotional exhaustion (Emery & Vanderberg, 2010; Kunter & Holzberger, 2014; Roth, 2014). Studies present that increasing motivation will be achieved by overcoming the negative teaching-related situations encountered by SETs during teaching (Emery & Vanderberg, 2010; Kaff, 2004); supporting professional development; providing managerial support; and increasing income levels (Borg & Riding, 1991; Goddard, O'Brien & Goddard, 2006; Kyriakau, 1987; Mearns & Cain, 2003; Platsidou, 2010).

The findings also exhibited that as the levels of depersonalization increase, the levels of creative thinking, self-discipline, novelty-seeking, courage, curiosity, and flexibility decrease; and there is no relationship between emotional exhaustion and doubt. Gladding (2011) expressed that among the fundamental characteristics of creative people are being open to new ideas, having a high level of flexibility against uncertainty, being interested, curious, and energetic, having a vivid imagination and humor, being hardworking and determined, and being motivated to produce different works. When the study results are assessed, it is understood that the answers were given by SETs in the opposite direction of the mentioned characteristics. Robinson (2008) stated that everyone has creative characteristics, but these are related to different processes and environments. In addition, Doğan (2015) pointed out that the development of creativity depends on the proper arrangement in the environment, and the existing creativity does not reveal itself when the environment is not suitable. In general, it is understood that the work environment is crucial in supporting creativity. According to the study findings (Memduhoğlu, Uçar & Uçar (2017)) and SET responsibilities, appreciating employees' creative ideas, cooperating, and providing rewards,

bonuses, and so on, promotes creativity, which is important for SETs as well. Providing support for the issues, as suggested by researchers, can be said to reduce depersonalization and burnout in SETs.

Lastly, according to the analysis results, as the levels of personal achievement increase, the levels of creative thinking, self-discipline, novelty-seeking, courage, curiosity, doubt, and flexibility increase, too; as the levels of personal achievement decrease, the levels of creative thinking, self-discipline, novelty-seeking, courage, curiosity, doubt, and flexibility decrease, too. Türkoğlu & Özgenel (2021) showed that people need creative thinking in order to be successful and happy in business life. Furthermore, failure brings about burnout in SETs (Emery & Vanderberg, 2010). Therefore, the result is not surprising when we look at the findings achieved via the burnout dimension. In sum, it can be said that the relationship between success and burnout in SETs is tightly linked to each other. It should be once again emphasized that teachers should participate in in-service training, join different social activities, and receive support from their family and friends in terms of social support, in order to increase their individual successes (Batained & Alsagheer, 2012; Emery & Vanderberg, 2010).

Conclusion

SETs are the people who teach high-risk students, but the process makes them high-risk study groups, too. At this point, it was revealed as a result of studies that they have a tendency to stress and burnout, which increase with low job satisfaction and self-efficacy (Emery & Vanderberg, 2010). This study also showed that SETs experience burnout and therefore cannot think creatively. The burnout of SETs is more or less directly associated with job satisfaction (Chaplain, 1995; Mearns & Cain, 2003). Here, it is crucial to ensure the teachers' satisfaction in the work environment. Happy and successful SETs in business life will undoubtedly appear as teachers with a high creative thinking tendency. Thus, in order to increase the teachers' creative thinking tendency, they should first be enabled to be happy in business life. These can be provided through in-service training, education that will allow scientific-based practices to be reflected in the classroom environment, and good salaries.

Recommendations

SETs do not only teach in the classroom environment. Additionally, these teachers have a broad range of responsibilities outside of the classroom, including caring for their own students, staying in constant contact with the student's family, attending special education board meetings, creating IEPs and participating in IEP teams, consulting other teachers in mainstreaming schools, and working with all special education stakeholders. All these factors are included among the responsibilities of the teachers so that students with special needs can benefit from the education at the school at the highest level. Coping with these situations can also be very tiring and wearisome for SETs. For instance, the actual implementation of assistant personnel practices to support teaching will reduce the workload of the teachers in the classroom environment. Furthermore, arrangements regarding making additional payments for all responsibilities of SETs other than teaching can also increase their quality of life by reducing their burnout in this process. Finally, teaching creative thinking courses not only to teacher candidates working with groups with intellectual giftedness but also to all special education teachers will contribute positively to the professional lives of these teachers.

Contribution Rate of the Author (s)

The authors have contributed equally.

Conflicts of Interest

There aren't any potential conflicts of interest.

Ethical Approval (only for necessary papers)

Ethical permission (18.01.2022-E.20439) was obtained from Istanbul Sabahattin Zaim University for this research.

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An Examination of Teachers' Use of Metacognitive Strategies in Supporting the Reading Comprehension Skills of Children with Learning Disabilities

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An Examination of Teachers' Use of Metacognitive Strategies in Supporting the Reading Comprehension Skills of Children with Learning Disabilities

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Abstract

Metacognitive reading strategies are to facilitate the reading processes of students, to give them the chance to monitor and control the reading process, and to regulate the reading process. While many typically developing children can acquire these cognitive processes, children with learning disabilities (LD) have difficulties. They also have more limited memory than typically developing children. It is an effective method for making it easier for children with limited memory and learning difficulties to remember the information in the text and thus increase their understanding. The most effective people in teaching metacognitive reading strategies are teachers. Teachers' knowledge level of metacognitive strategies affects the reading comprehension success of students with LD (Oslund et al., 2016). Therefore, in this study, it aims to examine the views of teachers on the teaching of metacognitive reading strategies to improve the reading comprehension of children with LD. The "Metacognitive Reading Strategy Usage Scale" (MRSUS) developed by Özen and Durkan (2016) was used to evaluate the teaching of metacognitive reading strategies that teachers use to improve reading comprehension. The MRSUS is a tool that evaluates a set of strategies that children use before, during, and after reading. MRSUS scores of 204 teachers participating in the study were examined. Got results; presented in the findings section.

Keywords: learning disability, Teacher training, Reading difficulties, Metacognitive learning strategies

Introduction

Reading comprehension is one of the basic tools necessary for learning. However, when the reading performance of students in different countries is examined, it is seen that many students perform below what they should be (OECD, 2019). The risk of failure in reading comprehension is always higher for students with learning disabilities (LD), who are in the risk group because of poverty or lack of stimuli, compared to their normally developing peers (McFarland et al., 2017). According to a study conducted on the subject, it was stated that especially students with LD (Tarchi, 2015) and students affected by poverty and lack of stimuli (Oslund et al., 2016) were all deficient in skills such as reading comprehension and especially making inferences. While teaching students with such difficulties to read with comprehension, special education teachers need to make instructional adaptations, use teaching methods and materials, and make frequent evaluations to ensure the functionality of the individualized education plan (Edmonds et al., 2009). Children with LD need to exert more effort to read with understanding compared to their normally developing peers. For example, secondary school students are required to read and understand a greater amount of information in subject areas than primary school students (Gajria et al., 2007). However, it is estimated that 21% of middle school students with LD are at least five grades below their peers in reading (National Joint Committee for Learning Disability, 2008). Reading comprehension of the text and gaining information can be difficult, especially for middle school students with LD (Edmondset et al., 2009). Reading comprehension can be defined as a skill that requires students to interact with the text they read and make sense of stories or passages (Honig et al., 2008). At the secondary school level, as text structures become more complex, it becomes increasingly difficult for children with LD to make sense of them (Gardill & Jitendra, 1999). Comprehension is called "the essence of reading" (Durkin,1993). Researchers agree that the ultimate purpose of reading written materials is comprehension (Edmonds et al., 2009; Honig et al., 2008). Negative statistics on reading comprehension for

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students with LD underscore the fact that comprehension can actually be difficult for many students. Strategy teaching, which is used to increase comprehension, emerges as a functional way to help students understand the purpose of reading and equip them with the practical skills necessary to understand the text (Honig et al., 2008). Reading strategies provide a way for readers to access the meaning of the text. Studies show that the correct use of reading strategies can facilitate understanding of the text (Hagaman et al., 2012; Klingner et al., 2015). In this respect, successful readers understand, discover, and use reading strategies better. (Van Keer and Verhaeghe, 2005; Westbrook et al., 2019). Readers with low reading comprehension performance cannot discover and apply efficient reading strategies or techniques on their own and may not understand the text because of a lack of knowledge of reading strategies (Daly et al., 2015). As a promising teaching approach, teaching reading strategy is thought to be effective in helping readers with low reading comprehension performance (Daly et al., 2015; Konza, 2006; Roberts et al., 2013). There are many methods, techniques, and strategies used by teachers in the literature to support reading comprehension. One of them is teaching metacognitive strategies. Metacognitive reading strategies are tactics used by the reader to plan, monitor, evaluate, and use the information given to the reader. Metacognitive reading strategies are used to discover important details while reading, to keep them in mind, to combine new information with old ones, to produce new information that is not in the text, to interpret the text, to use personal judgments and to make sense of it. Metacognitive strategies; It allows the reader to form insight, find the main idea, determine the author's purpose and predict the content, make deep meaning and literary inferences, and use the context of the text to understand unknown words and judgments (Mokdari and Reichard, 2002). Students with LD have significant difficulties in using cognitive and metacognitive strategies (Anastasiou & Griva, 2009; Botsas, 2017; Wigent, 2013) and it has been stated in various studies that the inability to use these strategies effectively is the main reason that negatively affects their understanding (Hagaman et al., 2012; Mastropieri et al., 2003; Swanson and Vaughn, 2010). Students with LD cannot establish a purpose for reading, monitor their own comprehension, organize their reading according to the difficulty level of the text, or make inferences (Sencibaugh, 2007). Through strategy teaching, students with LD can be provided with the skills to cope with all these difficulties. When studies evaluating intervention studies aimed at improving the comprehension skills of students with LD are examined, it is seen that strategy teaching has positive effects on reading comprehension (Edmonds et al., 2009; Gajria et al., 2007; Gersten et al., 2001; Kim et al., 2012; Mastropieri et al., 2003). Some of these studies state that the most important factor affecting the development of reading comprehension skills is cognitive and metacognitive strategy teaching (Gajria et al., 2007; Gersten et al., 2001; Kim et al., 2012; Swanson, 1999). Therefore, teaching and using metacognitive strategies to students with LD is very important for their reading comprehension skills. Teachers are the most effective people in teaching and using metacognitive reading strategies in terms of reading and reading comprehension. Furthermore, teachers should guide students in the use of strategy so that they can best interpret the text they read (Kana, 2014). Students ' use of metacognitive and cognitive strategies depends on their teachers' expertise in knowledge and skills on the subject (Başaran, 2013). In addition, the ability of students to read and understand a text is very important for their lifelong learning and its foundations are laid in primary school (Öztürk, 2012). Teacher competencies differ according to various demographic variables. As teachers' age and length of service increase, they are expected to gain experience and become more qualified in their profession (Pantić & Wubbels, 2010). In Turkey, the socioeconomic level of the region where the teachers work affects the self-development of the teacher (Ergül et al., 2014). In a study evaluating preschool teachers' knowledge of reading strategies, it was found that the knowledge level of teachers working in the low SEL region was low (Cunningham et al., 2009). The level of knowledge of teachers working with LD on strategies to improve reading comprehension differs according to the SEL of the region they work in (Talbott et al., 1994). Inclusive education and special education support services are provided to children with LD in Turkey. Primary school teachers or Turkish art teachers study reading skills with children with LD in general education classrooms. While special education teachers receive special education support services, they study reading skills with children with LD in resource rooms. Teachers' educational performances may differ depending on their field (Wake & Whittingham, 2013). Children with learning disabilities have the same or sometimes higher intelligence scores than typically developing children. However, limitations in attention and memory skills cause them to be unsuccessful in the academic field. These limitations also have an effect on reading comprehension skills. Children with learning disabilities need to use metacognitive strategies to overcome their difficulties in reading comprehension.

The use of metacognitive awareness and skills has an important effect on increasing students' academic success, and these skills can be developed through metacognitive teaching (Özsoy, 2008; Doğan, 2013; Karaman et al., 2014; Katrancı & Yang, 2013). Individuals with learning disabilities often experience metacognitive problems. These individuals have difficulties in acquiring metacognitive skills such as deciding on the difficulty level of a task, identifying and implementing strategies that will help them at school and outside of school, monitoring whether the strategy they choose and implement is working, and switching to a different strategy when necessary (Vuran, 2014). In order to acquire metacognitive awareness and skills, which have a very important

role in the success of students, educators need to teach these cognitive processes and skills to individuals and create awareness about these skills (Doğan, 2013; Katrancı & Yangın, 2013). Metacognitive learning strategies are strategies that allow students to control their own cognition (Boyacı, 2010) and are generally related to the awareness of which strategy will be more beneficial during the use of strategies in the reading process (Ülper, 2010). It is necessary to teach cognitive and metacognitive strategies and to raise awareness about these strategies in order to gain reading comprehension skills for students with learning difficulties and students with intellectual disabilities; that is, their metacognitive awareness should be developed in which situations and for what purpose the strategies will be applied (Doğanay-Bilgi, Özmen, 2014). Research on cognitive and metacognitive strategies provides a basis for understanding the processes involved in higher-order cognitive activities such as reading comprehension and also provides a foundation for process-based instruction. This study aims to determine the reading comprehension practices of teachers working with LD students that enable these students to develop metacognitive reading strategies. In the context of this purpose, answers to the following questions are sought:

1. How does it score on the Teachers' Metacognitive Reading Strategies Utility Scale (MRSUS)?
2. Do teachers' scores from MRSUS sub-dimensions differ according to the socio-economic level (SEL) of the region they work in?
3. Do teachers' scores from MRSUS sub-dimensions differ according to their length of service?
4. Do teachers' scores from MRSUS sub-dimensions differ according to their branches?
5. Do teachers' scores on MRSUS sub-dimensions differ according to whether or not they take courses related to learning disabilities?

Method

Design

In this study, a causal, descriptive survey model was used to examine the use of metacognitive strategy skills of Turkish teachers, primary school teachers, and Special Education teachers working with LD, in terms of age, length of service, socio-economic level, and whether they took/did not take courses related to LD. The descriptive model (screening model) is a research approach that aims to describe past or present conditions as they are (Büyüköztürk et al., 2010).

Participants

We conducted the research in Ankara, Turkey. The study group consisted of a special education teacher, a primary school teacher, and Turkish teacher who worked with LD in reading comprehension. A Confirmatory Factor Analysis was performed with 236 participants analyzed on research questions made with 200 other people. We have shown the study group characteristics in Table 1.

Table 1. Teachers' Demographic Information

Length of Service	Teacher's Branches			Total
	Primary School Teacher	Special Education Teacher	Turkish Teacher	
0-5 years	39	121	20	180
6-10 years	46	36	4	86
11-20 years	42	32	9	83
21 years and over	36	13	38	87
Total	163	202	71	436

Materials

The researchers created an information form to collect demographic information from the teachers who participated in the study (length of service, age, socioeconomic level, branch, and whether or not they were taking a course related to learning disability). Second, we used the "Metacognitive Reading Strategies Utility Scale" (MRSUS) to assess how teachers use metacognitive strategies. It is a measurement tool that evaluates the extent to which teachers use metacognitive strategies consisting of pre-reading, reading, post-reading, and reading evaluation dimensions. The scale developed by Özen and Durkan (2016) consists of four sub-dimensions and 25 items. Since the scale was developed for pre-service teachers, we need to do CFA. Since we work with different teacher groups (primary school teachers, Turkish teachers, and special education teachers),

we applied for confirmatory factor analysis (CFA). (H): Items in this sub-topic belong to metacognitive reading strategies during the reading preparation (planning) phase (5 items, numbered H1-5) The highest score that can be taken from this section is 25. A high score shows the utility level of applications during the planning phase is high. During reading (E): Items in this sub-topic belong to metacognitive reading strategies during the reading (self-monitoring) phase (5 items, numbered E6–10). A high score taken from this section shows the utility level of applications during the self-monitoring phase is high. After Reading (S): Items in this sub-topic belong to metacognitive reading strategies during the after-reading phase (7 items, articles: S11-17). A high score taken from this section shows the utility level of applications during the after-reading phase is high. Reading Evaluation (D): Items in this sub-topic belong to metacognitive reading strategies during the reading evaluation phase after reading. (8 items, items: D18-25). A high score taken from this section shows the utility level of applications during the reading evaluation phase is high. The results of the analysis are shown in figure 1.

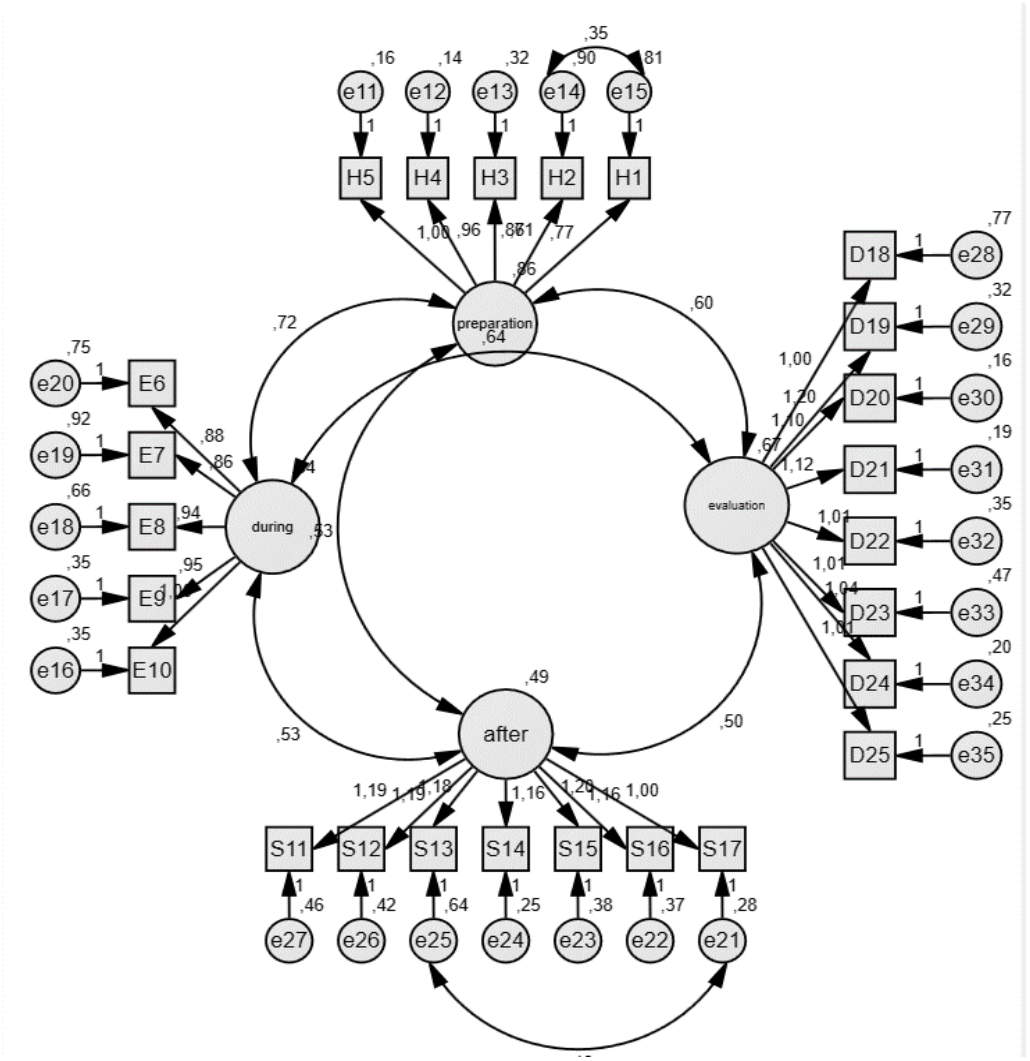

Figure 1. A confirmatory factor analysis model for metacognitive reading strategies utility scale (Standardized Values)

During the assessment of the confirmatory factor analysis (CFA) results, Chi-square and degrees of freedom values were identified as $\chi 2=648.012$ (sd=267, $p<.01$) and the ratio of $\chi 2/sd=2.42$ was obtained. In this study, it could be concluded that the fit between the model obtained as a result of CFA and the data suggests a perfect fit. The fit indices detected as a result of the CFA are presented in Table 2.

Table 2. The fit indices obtained as a result of CFA

The Fit Criteria	Perfect Fit	Acceptable Fit	In the Scale Model observed value
$\chi 2/d$ (648,012/267)	$\chi 2/d<3$	$4<\chi 2/d<5$	2.42
RMSEA	0<RMSEA<0.05	0.05<RMSEA≤0.08	0.08
S-RMR	0≤S-RMR≤0.05	0.05≤S-RMR≤0.1	0.06
NNFI	0.97≤NNFI≤1	0.90<NNFI<0.97	0.90
CFI	0.97≤CFI≤1	0.90<CFI<0.95	0.91
GFI	0.95≤GFI≤1	0.90<GFI<0.95	0.92
AGFI	0.90≤AGFI≤1	0.85<AGFI<0.90	0.88
IFI	0.95≤IFI≤1	0.90<IFI<0.95	0.91

(Kelloway, 1989; Schumacker ve Lomax, 1996; Sümer,2000; Tabachnick ve Fidell, 2001; Thompson, 2004; (Hu ve Bentler, 1999; Thompson, 2004).

When the CFA results are examined, it is seen that the four-dimensional structure of the scale is confirmed. For the reliability analysis of the scale, a Cronbach Alpha reliability test was performed for each of the sub-dimensions. Accordingly, the results were as follows for the reading preparation sub-dimension as.88, the during-reading sub-dimension as.85, the after-reading sub-dimension as.91, and the reading evaluation sub-dimension as.94. As a result of the validity and reliability analyses, it is possible to say that the scale is a valid and reliable scale.

Procedure and The Analysis of Data

Due to the COVID-19 pandemic, the scales were delivered to the predetermined teachers via Google Forms.

The total scores obtained from the subscales of the scale were analyzed according to the variables included in the research questions. Detailed results of the analysis are presented in the result section.

Results

The results and findings of the analysis performed to answer the research questions of the study are presented in this section. The scores that the teachers attained from the sub-dimensions of the scale were evaluated comparatively in terms of various variables. Demographic information regarding these variables is shown in Table 3.

Table 3. Teachers' Demographic Information

The Length of Service	Teacher's Branches	Taking course/Not taking course		Total
		Yes	No	
0-5 Years	Primary School teacher	11	7	18
	Special Education Teacher	50	4	55
	Turkish Teacher	6	3	9
	Total	67	14	82
6-10 Years	Primary School teacher	15	7	22
	Special Education Teacher	16	0	17
	Turkish Teacher	1	1	2
	Total	32	8	41
11-20 Years	Primary School teacher	11	8	19
	Special Education Teacher	12	3	16
	Turkish Teacher	3	1	4
	Total	26	12	39
21 years and over	Primary School teacher	12	6	18
	Special Education Teacher	6	0	6
	Turkish Teacher	13	5	18
	Total	31	11	42
Total	Primary School teacher	49	28	77
	Special Education Teacher	84	9	94
	Turkish Teacher	23	10	33
	Total	156	47	200

The extreme values of the four sub-dimension scores of the Metacognitive Reading Strategy Utility Scale (MRSUS) of 204 teachers included in the analysis were converted into the standard scores (z scores) and the extreme values were examined. In the normal distribution curve, the z scores are between +3 and -3 (Deniz, 2020). As a result, four participants' data were excluded from the analysis because their z scores were outside the range of +3 and -3. In order to find an answer to the first research question of the study, "How do teachers score on the Metacognitive Reading Strategies Utility Scale (MRSUS)?", descriptive statistics such as the mean, standard deviation, mode, and median of the scores of the teachers attained from the sub-dimensions of the scale were estimated. The results of the analysis are presented in Table 4.

Table 4. Descriptive Values Regarding the Scores of Teachers' from Sub-Dimensions of MRSUS

Dimensions	N	Min. Score	Max. Score	Mean Score	The Success Percent (%)	SD
Reading Preparation	200	7	25	19	76	3.95
During Reading	200	5	25	17	68	4.33
After Reading	200	10	30	24	80	4.59
Reading Assesment	200	12	40	28	70	6.63

The results of the teachers' scores from the scale are clearly expressed in Table 4. Scores and standard deviations related to the sub-dimensions of the scale are included. An ANOVA was conducted to determine whether the scores obtained from the sub-dimensions of the scale differ according to the socio-economic level studied. Before we made ANOVA, we made sure that the distribution satisfied the assumptions of normality. The results of the analysis are presented in Table 5.

Table 5. Normality Test Results

Sub-dimensions	N	Min. score	Max. Score	X	Median	Mod	SD	Skewness	Kurtosis
Reading Preparation	200	7	25	19	20	20	3.95	-.60	.21
During Reading	200	5	25	17	17.5	15	4.33	-.39	-.10
After Reading	200	10	30	24	25	30	4.59	-.95	.53
Reading Assesment	200	12	40	28	29	31	6.63	-.19	-.51

When the results of the n ormality test were assessed, it was assumed that the scores of the teachers from the sub-dimensions of the scale were normally distributed with regard to the skewness and kurtosis values. In the evaluation of the values related to the normality assumption in the literature, it was proposed that a skewness value of less than -3.0 and a kurtosis value of less than 3.0 indicate a normal distribution (Tabachnick & Fidell, 2001). The histogram plot of the distribution of subscales is shown in Figure 2.

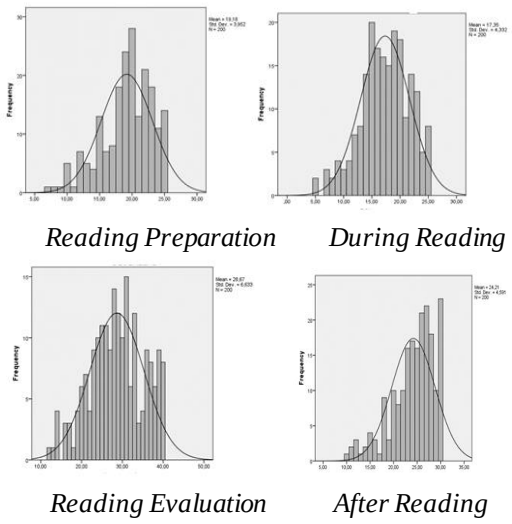

Figure 2. The Scores of Teachers Regarding the Sub-dimensions of MRSUS

After ensuring a normal distribution of data, a one-way ANOVA was carried out in order to compare the scores of the teachers from the sub-dimensions of MRSUS according to the socioeconomic status of the area where they work. ANOVA results are presented in Table 6.

Table 6. ANOVA Results for MRSUS according to SEL

	The source of the variance	Total of the squares	df	Mean of squares	f	p
Preparation sub-dimension	Between groups	24.386	2	36.193	4.59	.02
	Within groups	3083.134	197	15.650		
	Total	3107.520	199			
During-reading sub-dimension	Between groups	10.719	2	18.906	3.85	.00
	Within groups	3724.476	197	5.359		
	Total	3735.195	199			
After- reading sub-dimension	Between groups	2.771	2	21.578	3.65	.00
	Within groups	4191.824	197	12.856		
	Total	4494.595	199			
Reading Assesment sub-dimension	Between groups	23.733	2	44.317	3.74	.00
	Within groups	8730.487	197	11.86		
	Total	8754.220	199			

After the results of the analysis were examined, it was obvious that the scores obtained by the teachers from the sub-dimensions of MRSUS differed significantly according to SEL. The findings were as follows; reading preparation sub-dimension, $F(2, 197)=4.59$, $p<.05$; during reading sub-dimension $F(2, 197)=3.85$, $p<.05$; after-reading sub-dimension $F(2, 197)=3.65$, $p<.05$; reading evaluation sub-dimension, $F(2, 197)=3.74$, $p<.05$. In other words, teachers' average scores vary depending on the SEL of the area where they work. First, Levene's test was used to determine whether the variances of the group distributions were homogeneous, and the variances were found to be homogeneous (LF = 0.950; 05).nm Above all, the Scheffe multiple comparison technique, which is a widely used technique, was preferred in the case of the homogeneity of variance. The reason why the Scheffe test was preferred is that the test is sensitive to alpha-type errors. According to the results of the Scheffe multiple comparison analysis, a significant difference was identified in favor of the teachers working in the upper socioeconomic area in all sub-dimensions of the MRSUS. In the reading preparation sub-dimension, the mean scores of teachers working in the upper socioeconomic area (X=20.51) were determined as statistically significantly higher than the mean scores of the teachers working in the middle socioeconomic area (X=19.21), and lower (X=18.17) socioeconomic area.

In order to find an answer to another research question of the study, " Do the scores obtained by the teachers from the sub-dimensions of MRSUS differ according to their length of service?", the scores of the teachers from the sub-dimensions of the scale were compared using One-Way Analysis of Variance (ANOVA). The results are presented in Table 7.

Table 7. ANOVA Results of MRSUS by the Length of the Service

	The source of the variance	Total of the squares	df	Mean of squares	f	p
Preparation sub-dimension	Between groups	35.309	3	11.77	.751	.523
	Within groups	3072.211	196	15.67		
	Total	3107.520	199			
During-reading sub-dimension	Between groups	21.128	2	7.04	.372	.774
	Within groups	3714.067	196	18.94		
	Total	3734.152	199			
After- reading sub-dimension	Between groups	82.170	3	27.390	1.305	.274
	Within groups	4112.425	196	20.982		
	Total	4194.595	199			
Reading Assesment sub-dimension	Between groups	246.292	3	82.097	1.892	.132
	Within groups	8507.928	196	43.408		
	Total	8754.220	199			

When the table was examined, the difference between the groups in all sub-dimensions of the scale was not identified as statistically significant. In other words, the average scores of the teachers included in the study with different lengths of service were identified to be very close to each other. In seeking an answer to the other research question of the study, " Do the scores that teachers acquire from the sub-dimensions of MRSUS differ according to the teacher's branches?", the scores of the teachers from the sub-dimensions of the scale were compared using One-Way Analysis of Variance (ANOVA). The results are shown in Table 8.

Table 8. Teachers' ANOVA Results According to Their Branches

	The source of the variance	Total of the squares	df	Mean of squares	f	p
Preparation sub-dimension	Between groups	12.406	2	6.202	.395	.674
	Within groups	3095.117	197	15.711		
	Total	3107.520	199			
During-reading sub-dimension	Between groups	9.659	2	4.829	.255	.775
	Within groups	3725.536	197	18.911		
	Total	3735.195	199			
After- reading sub-dimension	Between groups	58.677	2	29.339	1.397	.250
	Within groups	4135.918	197	20.995		
	Total	4194.595	199			
Reading Assesment sub-dimension	Between groups	65.694	2	32.847	.745	.476
	Within groups	8688.526	197	44.104		
	Total	8754.220	199			

After the examination of Table 8, the difference between the groups in all sub-dimensions of the scale was not statistically significant. In other words, the average scores of teachers from different branches (special education, primary school teachers, and Turkish teachers) included in the study were very close to each other.

In order to answer the last research question of the study, "Do the scores that teachers obtain from the sub-dimensions of MRSUS differ according to whether they take courses related to LD or not?", the scores of the teachers from the sub-dimensions of the scale were compared using the t-test for independent groups. The

results are shown in Table 9.

Table 9. T-test Results for Mean Score Comparisons According to Whether Teachers Take Learning Disability Courses or Not

	Group	n	X	SD	Mean	t	df	p
Reading sub-Dimension	Taking course	130	18.95	3.91	2.85	3.43	198	.005
	Not taking course	70	16.10	7.85				
During Reading sub-Dimension	Taking course	130	17.10	4.11	2.20	2.65	198	.002
	Not taking course	70	14.90	7.65				
After Reading sub-Dimension	Taking course	130	24.00	4.68	3.80	3.73	198	.003
	Not taking course	70	20.20	9.70				
Reading Assesment sub-Dimension	Taking course	130	28.46	6.63	2.85	3.07	198	.010
	Not taking course	70	24.47	11.71				

After the examination of Table 9, the mean scores of the teachers' sub-dimensions of MRSUS differ significantly according to whether they have taken courses related to LD or not ($t(198)=3,43$, $p>.05$).

Discussion, Conclusion, and Recommendations

In this chapter, in the findings section, the results obtained were discussed in the context of the cause-effect relationship. This study aims to determine the views of teachers working with LD students on reading comprehension practices that enable their students to develop metacognitive reading strategies. It is suggested that children with LD have difficulties with reading, one of the academic skills (Lyon et al., 2003). In addition, many studies have shown that metacognitive strategies improve reading comprehension in students with LD (Gajria et al., 2007; Gersten et al., 2001; Kim et al., 2012; Swanson & Vaugh, 2010). Considering the importance of metacognitive skills for LD students' reading comprehension skills, their teachers have taken on important responsibilities.

In searching for an answer to the first research question of the study, "How do teachers score on Metacognitive Reading Strategies Utility-Scale (MRSUS)?", the scores of the teachers from all sub-dimensions of the scale were analyzed using descriptive statistics methods. The results revealed that the teachers' scores were good except for the "during reading" dimension of the scale. Kutlu and Çok (2002) asserted that one is accepted as successful if he/she completes the scale successfully at a rate of 70% or over. It was observed that the teachers achieved 76% success in the reading preparation dimension, 68% during the reading dimension, 80% after the reading dimension, and 70% in the reading evaluation dimension. According to these results, teachers were determined to be successful except during the reading dimension, where their success rate during the reading dimension was identified as moderate. In a study conducted in Turkey, Sulak and Behriz (2018) showed that teachers showed moderate success in using metacognitive strategies in their study with normally developing children. Teachers working with LD are expected to master more metacognitive strategies than teachers working with normally developing children. The fact that the teachers in this study were better than other teachers in different studies in the literature may be due to their previous experience working with LD. After the evaluation of the studies in the literature, it was often shown that teachers who try to enhance the reading skills of children with LD should use metacognitive methods (Palladino et al., 2000). Another reason for attaining good scores of teachers working with LD is that all teachers in Turkey take undergraduate courses about children with special needs. Teachers who have completed all teaching programs complete their education by knowing what to do and how to help children with special needs. In addition, the professional development of teachers continues through in-service training courses provided by the Ministry of National Education.

Teachers' metacognitive reading strategy utility-scale scores were evaluated according to another variable, namely socio-economic level. The scores of the teachers were compared according to the socio-economic levels

of the areas where they work in three categories: low, middle, and upper. As a result of the analysis, the scores of the teachers working in upper socioeconomic areas were determined to be better than the scores of the teachers working in the low and middle socioeconomic areas in all subscales of the scale. No statistically significant difference was identified between low and middle socioeconomic areas. This result suggests that the families of children from low socioeconomic status are not interested in their children's education. This may be related to the decrease in the teacher's motivation and his giving up on the reading comprehension instruction of the child. In studies, it was observed that the socio-economic level variable had an impact on teachers' knowledge about students with LD, their acknowledgment of the students in this group, and having information about what interventions they should apply (Moothedath & Vranda, 2015). It is suggested that the knowledge level of the teachers working in the upper socioeconomic areas about the children diagnosed with LD was better than the teachers working in the lower and middle socioeconomic areas (Atanga Jones et al., 2020). In a reading intervention-based study conducted with LD, a reading comprehension intervention program was applied to children, and the results were compared in terms of the SEL levels of the children. According to the results obtained from the research, it was discovered that the children from the upper socioeconomic areas were more successful than the children from the lower and middle socioeconomic areas (Talbott et al., 1994). According to the assessment of the research findings and the results of all the studies in the literature altogether, an overlap was identified between all the results. In addition, it could be concluded that the increased success level of students with LD in the upper socioeconomic areas mentioned in the literature may have positively influenced the efficiency of teachers in the utilization of metacognitive strategies. Ergül et al. (2015) evaluated teachers who use interactive book reading methods in kindergartens in different socioeconomic areas. They revealed that teachers working in the upper socioeconomic areas applied reading preparation, during reading, after reading, and reading evaluation strategies completely, while the teachers working in the lower and middle socioeconomic areas insufficiently implemented these strategies. Teachers working in upper socioeconomic areas were more successful in the utilization of metacognitive strategies than teachers working in lower and middle-upper socioeconomic areas.

The scores of the teachers participating in the study from the MRSUS were examined in four categories according to their length of service: 0-5, 6-10, 11-20 years, and 21 years and over. The scores of the teachers from each sub-dimension of the scale were compared separately according to their length of service, and no statistically significant difference was detected between them. In the literature, it is shown that the level of knowledge and success of teachers escalate as their length of service increases (McGee & Richgels, 2003; Pintrich, 2002). Besides, it is seen that the results obtained in this study do not coincide with the results detected in the studies in the literature. This study only aimed to investigate the metacognitive strategy use levels of teachers who do reading studies with LD. For this reason, the prerequisite of studying reading skills with LD was required of the participants included in the study. Thus, all teachers who try to enhance reading skills with LD should know metacognitive strategies and use them effectively. The teachers' focus on improving the reading skills of children with LD may have encouraged them to investigate metacognitive strategies and learn about their use extensively. Also, the experience gained by experienced teachers over the years may have eliminated discrepancies in knowledge between teachers who are at the beginning of their professional life, but who take undergraduate courses on metacognition. Thus, in some studies in the literature on the use of metacognitive strategies, it has been suggested that the length of service is not a variable that makes a difference (Durkan & Özen, 2016; Sulak & Behriz, 2018).

The study group of the research consists of Turkish teachers, primary school teachers, and special education teacher branches. When the scores of the teachers attained from the sub-dimensions of the MRSUS were compared according to their branches, no statistically significant difference was identified. After the studies in the literature are evaluated, it is concluded that primary school teachers are good at using metacognitive strategies such as reading preparation, during reading, after reading, and reading evaluation (Sulak & Behriz, 2018). Besides, it is revealed that the metacognitive strategy skills of the students in the Turkish language teaching program are successful in all areas. The utility of metacognitive strategies is a teaching method that special education teachers frequently apply to acquire the academic skills of children with special needs, especially in those with LD. In the special education teaching undergraduate programs, there is information on the metacognitive strategy use methods in the content of courses such as teaching reading to students with LD and special abilities and teaching Turkish to students with special needs. For this reason, teachers are expected to be successful in the utilization of metacognitive strategies. As it is obvious from the results, the scores of special education teachers from the subscales of MRSUS are successful. In the same way, the scores of the primary school teachers and Turkish teachers from the subscales of MRSUS are very good. When the scores of the teachers from the subscales of the MRSUS were compared according to their branches, no statistically significant difference was identified between their scores. Because of the courses of undergraduate programs for special education teachers, including mainly metacognitive strategies and their experience in working with

children with special needs, it could be expected that they would be better at using metacognitive strategies than other teachers. The fact that the primary school and Turkish teachers are actively studying reading skills with LD and that the metacognitive strategies method is the most commonly used method to enhance reading skills in these children may have increased their awareness of this issue and, consequently, may prevent the emergence of a difference between them. Along with the increase in awareness, teachers may have searched for their shortcomings and tried to improve them. This may have led to the disappearance of statistically significant differences they had when compared to special education teachers.

After all the findings obtained from the study are evaluated together, it could be proposed that the teachers who participated in the study are good at using metacognitive strategies while studying reading skills. Also, we could state that the strategies that teachers use only during a reading should be further developed. According to the findings detected after an examination of variables playing a role in the teachers' use of metacognitive strategies, it was revealed that taking courses related to LD and SEL in the area where they work was affecting the level of metacognitive strategy use. It was also observed that teachers working in the upper socioeconomic areas were better than those working in the lower and middle socioeconomic areas, and there was no difference between the lower and middle socioeconomic areas in terms of their performance. In our study, another variable that created a difference was whether or not teachers took courses for LD. It can be said that teachers who take lessons on LD are better at applying metacognitive strategies than those who do not.
According to the results obtained from the research, it was seen that the teachers working in the lower and middle socioeconomic regions used metacognitive strategies less. This situation may cause disadvantaged students with learning difficulties to fall behind even more. It can be suggested that teachers working in low and middle socioeconomic regions should be supported with in-service training programs. In addition, training programs can be organized for families and school personnel regarding the access of students with learning disabilities to special education support services.
In this study, data was collected only from teachers regarding the use of metacognitive strategies. Studies should be conducted by collecting data from students with learning disabilities in order to deal with the use of metacognitive strategies in all its dimensions. In addition, the study is limited to the participation of only 200 teachers from the province of Ankara. In order to generalize the results of the study, data can be collected from different cities in Turkey.

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The Relationship Between Metacognitive Awareness and Academic Procrastination Behavior: The Moderator Role of Gender and Grade Level

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The Relationship Between Metacognitive Awareness and Academic Procrastination Behavior: The Moderator Role of Gender and Grade Level

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Abstract

This research aimed to reveal the relationship between university students' metacognitive awareness (MA) and academic procrastination levels. Additionally, the moderator effects of gender and grade level in this relationship were examined. The quantitative research method was adopted, and descriptive and associational research designs were used. The sample consisted of 375 undergraduate students studying at Gaziosmanpaşa University in Tokat, Turkey. The data were collected using a demographic information survey and the, Metacognitive Awareness Scale, and Academic Procrastination Scale. The results showed that students have a low level of academic procrastination behavior and moderate to high level of cognitive awareness. There is a moderate, negative, and statistically significant relationship between academic procrastination behavior and MA; as MA increases, academic procrastination behavior decreases. Thus, MA is a significant variable in predicting academic procrastination; 17.8% of the variance in academic procrastination behavior is explained by MA. The moderator roles of gender and grade level in this relationship are not statistically significant.

Keywords: Academic procrastination, Metacognitive awareness, Moderator variable, Regression analysis, University students

Introduction

In its simplest form, procrastination refers to a person delaying something he/she should do. The reason for the delay is usually the person's reluctance to do the work in question (Oxford Dictionary, 2020). Although procrastination is often perceived as a negative behavior, this perception is not always true. There are situations in which procrastination is favorable and appropriate. For example, one can set the tasks to do in order of importance and postpone some tasks according to this order. Procrastination becomes a problem when people unreasonably delay the tasks that they deem important and aim to complete, to the extent that they feel worried and sad; turn the procrastination behavior into a habit; and get substandard results. In this case, one can consider procrastination as being pathological (Ferrari, 1991; Ferrari et al., 1995; Milgram, 1991; Rothblum et al., 1986; Steel, 2007; Van Eerde, 2003). Chronic procrastination is a common and relevant problem that can causes stress and leads to psychological function and adaptation disorders (Ferrari et al., 1995).

Procrastination behavior is mainly analyzed as a personality trait or in association with certain situations (Senécal et al., 1997; Steel, 2007; Taylor, 1979). As a personality trait, procrastination can be defined making postponement a habit in all areas, regardless of time or situation. Contrastingly, situational procrastination is transforming the act of procrastination into a habit for a specific circumstance (Senécal, Lavoi, 1997). One of the most common types of situational procrastination is academic procrastination (Can & Zeren, 2019).

Academic procrastination can be defined as usually or always delaying an academic task or assignment, causing a student to usually or always feel worried at a problematic level (Rothblum et al., 1986). This is a highly common behavior among university students (Çeri et al., 2015; Odacı & Kaya, 2019; Yurtseven & Doğan, 2019) because they have to deal with homework, exams, and different assessment activities in a limited time. Additionally, the stress caused by the students' desire to fulfill their responsibilities toward their families can cause them to have difficulties organizing their academic life, causing them to exhibit academic procrastination behavior (Balkıs, 2013). In turn, academic procrastination can lead to time and financial losses, such as failing a

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course, prolonging the education period, having a low academic average, and missing various educational opportunities (Aydoğan & Özbay, 2012).

Academic procrastination behavior has a complex structure, with various behavioral, cognitive, and emotional dimensions (Ferrari, 1991). The factors that affect academic procrastination behavior can be categorized as demographic and cognitive factors (e.g., age, gender, standardized exam results), personal factors (e.g., anxiety, pessimism, neurosis, job commitment), factors related to self-perception (e.g., self-esteem, self-efficacy), motivational factors (e.g., fear of failure, perfectionism, self-inhibition), affective factors (e.g., situational anxiety that includes test anxiety, depression, and low mood), and performance-related factors (e.g., time spent on completing the task, deadlines, course grades, overall academic average) (Van Erdee, 2003). Many studies investigate the relationship between academic procrastination behavior and different variables. Some of these studies are: the relationship between time spent on technology or technology/internet addiction and academic procrastination (Engin & Genç, 2020; Noise, 2016; Yang et al., 2019); the relationship between academic procrastination and variables such as perfectionism, motivation, self-regulation, hope, trait anxiety, irrational beliefs, self-efficacy, emotional intelligence, problem-solving, responsibility, and general competence (Çelikkaleli & Akbay, 2013; Çetin & Ceyhan, 2018; Ekşi & Dilmaç, 2010; Grunschel et al., 2016; Naktiyok & Kızıl, 2018; Odacı & Kaya, 2019; Sarıkabak et al., 2018; Wu & Fan, 2017; Yurtseven & Doğan, 2019; Yücel & Şen, 2019); the relationship between time management and academic procrastination (Aydın & Koçak, 2016); the relationship between academic procrastination and variables such as age, gender, grade level, department, place of residence, education level, and academic achievement (Çelik & Odacı, 2015; Doğan et al., 2014; Memnun & Akkaya, 2009; Ocak & Boyraz, 2016; Özer & Altun, 2011; Şirin & Duman, 2018; Yaycı & Düşmez, 2016); and the relationship between values and academic procrastination (Ayyıldız, 2016). Results reveal that there are relationships at varying levels between the aforementioned variables and academic procrastination. The determination of a relationship between academic procrastination behavior and variables such as self-regulation, self-efficacy, problem-solving, and general competence in the literature leads to the hypothesis that there could be a relationship between MA and academic procrastination (Bedel, 2017; Vural & Gündüz, 2019).

Metacognition, which is another variable of this research, is frequently referred to as "thinking about thinking." It is a regulatory system that helps individuals understand and control their own cognitive performance; moreover, it enables individuals to be responsible for their own learning (Jaleel, 2016). Metacognitive awareness (MA) is a competence that has significant effects on cognitive goals or tasks, metacognitive knowledge, cognitive actions, and cognitive strategies (Flavell, 1979). Fırat-Durdukoca (2013) stated that MA has three dimensions: personal awareness (PA), organizational awareness (OA), and judgmental awareness (JA). Personal awareness refers to what individuals do to perceive and solve a subject or problem that is related to them. Organizational awareness refers to individuals planning a process and acting in accordance with this plan when performing a task or producing a solution to a problem. Judgmental awareness refers to individuals' evaluation of the learning or solution process and alternatives for learning and problem-solving after its completion.

There are studies in the literature that investigate the relationship between MA and various variables. Some of the prominent variables can be listed as follows: self-efficacy, problem-solving, anxiety, epistemological beliefs, reading skills, questioning skills (Bars, 2016; Bedir, 2017; Koç & Aralan, 2017; Oğuz & Kutlu-Kalender, 2018; Sezgin, Bakır, & Gündoğdu, 2019), learning approaches (Şen, 2019), academic achievement (Ayaz, 2019; Kaya, 2019), gender, age, education level, seniority, and grade level (Baltacı, 2019; Cabı et al., 2016; Oğuz & Kutlu-Kalender, 2018).

However, studies in the literature investigating the relationship between MA and academic procrastination are limited. While some of the studies found a moderate and negative relationship between MA and academic procrastination (Price, 2017; Wong, 2012), other studies revealed a low-level and negative relationship (Çırıkçı, 2016; Vural & Gündüz, 2019). These differing results indicate a need for more research on the subject. In this study, the moderator roles of gender and grade level variables in the relationship between MA and academic procrastination behavior are examined. The reason for this is that some literature reported relationships between MA and academic procrastination and gender and grade level. According to Oğuz and Kutlu-Kalender (2018), gender and grade level differentiate MA. Memnun and Akkaya (2009) and Hashempour et al. (2015) found that the grade level differentiates MA. Meanwhile, Çelik & Odacı, (2015) and Yaycı & Dusmez (2016) found that academic procrastination behavior differed according to gender and grade level, while Şirin & Duman (2018) determined that academic procrastination differed according to gender. All these results lead to the hypothesis that gender and grade level may have an effect on the relationship between MA and academic procrastination. There has been no study investigating the moderator role of gender and grade level variables in this relationship.

Hence, investigating the relationship between academic procrastination and MA—in general and in the context of its sub-dimensions—and the moderator role of gender and grade level will be an important contribution to the literature.

Research Purpose

This study aims to reveal the relationship between university students' academic procrastination behavior and MA, including its sub-dimensions—personal, organizational, and judgmental awareness. Additionally, the moderator effect of gender and grade level variables on the relationship between students' metacognitive and academic procrastination behaviors is examined. The research questions are as follows:

1. What are the levels of university students' MA and its sub-dimensions—personal, organizational, and judgmental awareness—and academic procrastination behavior?
2. Do the personal, organizational, and judgmental awareness of university students significantly predict their academic procrastination behavior?
3. Does gender play a moderator role in the relationship between MA and academic procrastination behavior of university students?
4. Does grade level play a moderator role in the relationship between MA and academic procrastination behavior of university students?

Method

The study adopted a quantitative research method and used non-experimental descriptive and relational research designs (see Gliner et al., 2009). The sample was determined through the descriptive research method, and the levels of students' MA and academic procrastination behavior were presented using descriptive statistics. The relationship between MA and academic procrastination behavior and the moderator role of gender and grade level variables in this relationship was determined through correlational research methods.

Sample

The study sample consisted of 375 undergraduate students studying at the Gaziosmanpaşa University in Tokat, Turkey; the students were selected through the convenience sampling method. From the students included in the sample, 58% (f = 217) were female, and 42% (f = 158) were male; 25% (f = 94) were1st grade level; 14% (f = 53) were 2nd grade; 28% (f = 104) were 3rd grade; and 33% (f = 124) were 4th grade. Further, 40.5% of the students (f = 152) are undertaking their studies in the science and literature department; 34% (f = 127) in the Islamic studies department; and the remaining 25.5% (f = 96) in the education, social and human sciences, economics and administrative sciences departments, faculties of health and applied sciences, and gastronomy undergraduate program of a tourism and hotel management college.

Data Collection Tools

The research used a demographic information questionnaire and the Metacognitive Awareness Scale (MCAS), and Academic Procrastination Behavior Scale as data collection tools. The researcher prepared the demographic information questionnaire, consisting of three questions.

The MCAS was developed by Fırat-Durdukoca (2013). It consists of three dimensions and 18 items. The dimensions are PA, OA, and JA. This scale has a 5-point Likert-type rating. Fırat-Durdukoca (2013), reported the Cronbach's alpha reliability of the scale as .75 in her study. The scale's Cronbach's alpha reliability in this study was .90. Permission to use the scale was obtained via e-mail from the researcher who developed it.

Aitken (1982) developed the Academic Procrastination Behavior Scale, which was adapted into Turkish by Balkıs (2006). It consists of one dimension and 16 items and uses a 5-point Likert-type rating. Validity and reliability studies on the scale have found it valid, reliable, and usable. The Cronbach's alpha reliability coefficient of the scale was .89 in Balkıs's (2006) study. The scale's Cronbach's alpha reliability in this study was .86. Permission use the scale was obtained via e-mail from the researcher who adapted it into Turkish.

Data Collection and Analysis

The questionnaires were filled out online by the participants through one of the online questionnaire/scale preparation and application programs. With the help of lecturers working at the Gaziosmanpaşa University, some of the data collection was conducted through the online distance education portal, and some in face-to-face interactions with the participants. The data collection took an average of 10–15 minutes per participant. The entirety of the data were collected in the 2019–2020 spring semester.

The data analysis used the descriptive statistics of percentage, frequency, mean, and standard deviation, along with the Pearson correlation coefficient and multiple regression analysis. The SPSS 18.0 package program was used for the analyses.

Ethics Committee Approval

This study was conducted based on the permission obtained from the Tokat Gaziosmanpaşa University Social and Human Sciences Research Ethics Committee dated 02.03.2020, session number 02, and decision number 08.

Findings

Table 1 presents the descriptive statistics of the university students' academic procrastination tendencies, MA, and the sub-dimensions of MA, which are personal, organizational, and judgmental awareness.

Table 1. Descriptive statistics

Variable	N	Minimum	Maximum	$\bar{X}$	Ss
AP	375	1.00	4.25	2.13	.62
MA	375	1.39	5.00	3.79	.63
PA	375	1.25	5.00	3.83	.65
OA	375	1.67	5.00	3.87	.73
JA	375	1.25	5.00	3.59	.83

AP: Academic Procrastination, MA: Metacognitive Awareness, PA: Personal Awareness, A: Organizational Awareness, JA: Judgmental Awareness

As shown in Table 1, the academic procrastination scale mean score was 2.13; the total mean score of the MCAS was 3.79; the PA dimension mean was 3.83; the OA dimension mean was 3.87; and the JA dimension mean was 3.57. Both scales consisted of a 5-point Likert-type rating. High scores on the academic procrastination scale indicated high levels of academic procrastination, and high scores on the MCAS signified high levels of MA. One can derive that, students displayed a lower than medium and close to low level of academic procrastination behavior, and a higher than medium level of MA. Among the sub-dimensions of MA, OA has the highest mean score, and JA has the lowest.

Table 2 presents the correlation analysis between MA and its sub-dimensions and academic procrastination behavior.

Table 2. Correlation coefficients between metacognitive awareness and academic procrastination

		PA	OA	JA	MA
AP	Pearson Corr. Coef.	−.405	−.394	−.300	−.422
	p	.000	.000	.000	.000
	N	375	375	375	375

As shown in Table 2, there is a negative, moderate, and statistically significant relationship between academic procrastination behavior and MA ($r = -.422$, $p < .05$). Upon examining the relationship of PA, OA, and JA with academic procrastination behavior separately, there were statistically significant relationships between all three dimensions and academic procrastination. The relationship between PA and academic procrastination was at a moderate level ($r = -.405$, $p < .05$), whereas the relationship between OA and JA and academic procrastination was at a low level ($r = -.394$, $p < .05$; $r = -.300$, $p < .05$).

The study used stepwise multiple regression analysis to determine which of the personal, organizational, and judgmental awareness variables—the sub-dimensions of MA—are effective in predicting academic procrastination behavior.

The assumptions were checked before starting the analysis. The normal distribution and homogeneity distribution of residuals are presented in Figures 1-3. As seen in the figures, there was no violation that would prohibit the continuation of the analysis.

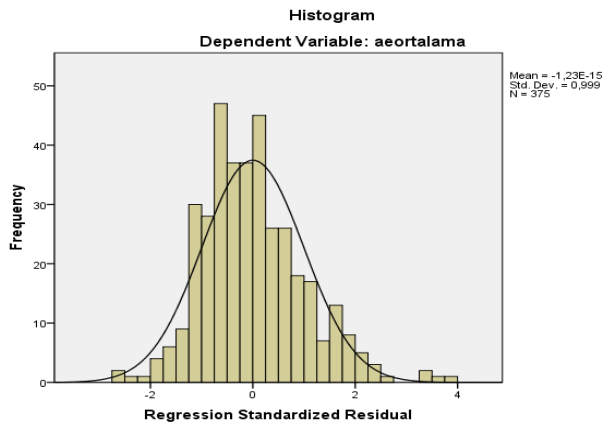

Figure 1. Residual distribution histogram

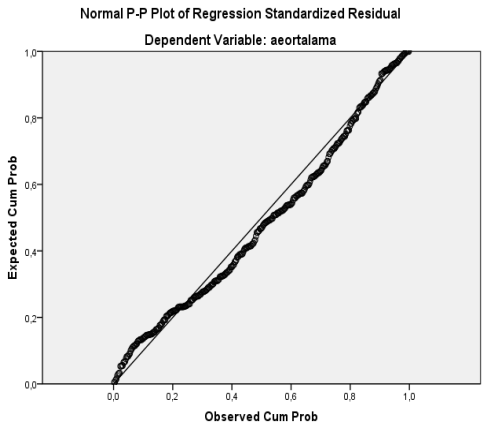

Figure 2. The P-P graph of the residuals

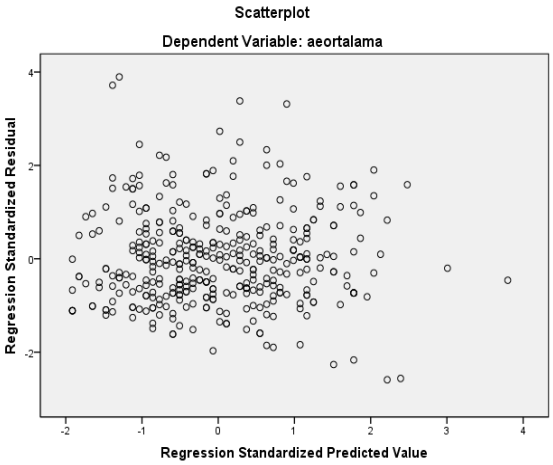

Figure 3. The scatterplot of the residuals

Table 3 presents the results of the multiple regression analysis.

Table 3. Regression analysis results to predict academic procrastination

Model	*B*	SE_B	*β*	*t*	*p*	*R*	R^2	*F*	*p*
Constant	3.634	.178		20.42	.000	.405	.164	72.99	.000
PA	−.391	.046	−.405	−8.54	.000				
Constant	3.774	.181		20.81	.000				
PA	−.243	.065	−.251	−3.72	.000	.431	.185	42.36	.000
OA	−.183	.058	−.213	−3.16	.002				

From Table 3, it can be seen that PA and OA, which are two of the three dimensions of MA, significantly predict academic procrastination behavior. Judgmental awareness was excluded from the analysis because it did not significantly contribute to the model. The first model analyzed PA only, while the second model analyzed PA and OA together. Both models are statistically significant ($F_{df\,(1.373)} = 72.99$, $p < .05$; $F_{df\,(1.372)} = 42.36$, $p < .05$). Personal awareness, considered alone, explains about 16% of the variance in academic procrastination; when considered together with OA, it explains 18.5% of the variance. Effect sizes (Cohen f^2) were .196 for the

first model, meaning medium effect (*VIF* = 1.196, tolerance = .836), and .227 for the second model, meaning medium effect also (*VIF* = 1.227, tolerance = .815) (see Cohen, 1988).

The study used dummy coding on the gender variable to determine the moderator role of gender in the relationship between MA and academic procrastination (Figure 1). The male category was accepted as the reference value and coded female students as 1 and male students as 0. Further, the interaction between the MA variable and the gender variable was dummy-coded. In addition, the regression analysis included MA in the first model and the interaction variable in the second model in predicting academic procrastination.

Table 4. The moderation analysis for the variable of gender

Model	*B*	SE_B	β	*t*	*p*	*R*	R^2	R^2 *change*	
								F	*p*
Constant	3.715	.178		20.86	.000	.422	.178	80.88	.000
MA	−.417	.046	−.422	−8.99	.000				
Constant	3.735	.179		20.87	.000				
MA	−.433	.048	−.438	−8.94	.000	.425	.181	1.25	.264
Interaction (MA*Gender)	.017	.016	−.055	1.12	.264				

Model[1]*:* $F_{df(1,373)} = 80.88\ p < .05$*; Model*[2]*:* $F_{df(2,372)} = 41.09\ p < .05$

As presented in Table 4, MA is a significant variable in predicting academic procrastination behavior (β = −.422, $p < .05$). The MA variable explains 17.8% of the variance in academic procrastination behavior. There is a statistically significant decrease in academic procrastination behavior as MA increases. The moderator role of gender in this relationship is not statistically significant [$\Delta R^2(R^2 2\text{-}\ R^2 1) = .003$, p = .264; β = −.055, p = .264]. Being male or female does not significantly differentiate the relationship between the participants' MA and academic procrastination behavior. The effect sizes (Cohen f^2) were .216 for the first model (*VIF* = 1.216, tolerance = .822) and .221 for the second model (*VIF* = 1.221, tolerance = .819). Both effect sizes indicate medium effect.

The study used dummy coding on the grade level variable to determine the moderator role of grade level in the relationship between MA and academic procrastination. The first-year student group was the reference category, based on the hypothesis that university education level would increase MA. Dummy coding was performed for the second, third and fourth-year students. The interaction of the MA variable with the dummy coding of each grade level was then calculated. The regression analysis included MA in predicting academic procrastination in the first model, and the three interaction variables obtained together with MA were included in the second model during the analysis.

Table 5. The moderation analysis for the variable of grade level

Model	*B*	SE_B	β	*t*	*p*	*R*	R^2	R^2 *change*	
								F	*p*
Constant	3.715	.178		20.86	.000	.422	.178	80.88	.000
MA	−.417	.046	−.422	−8.99	.000				
Constant	3.687	.179		20.58	.000				
MA	−.404	.050	−.409	−8.14	.000				
Interaction (MA*2nd grade)	.024	.026	.050	.908	.364	.430	.185	1.05	.369
Interaction (MA*3th grade)	−.010	.021	−.029	−.481	.631				
Interaction (MA*4th grade)	−.019	.020	−.055	−.908	.364				

Model[1]*:* $F_{df(1,373)} = 80.88\ p < .05$*; Model*[2]*:* $F_{df(4,370)} = 21.02\ p < .05$

As shown in Table 5, the grade level variable did not play a moderator role in the relationship between MA and academic procrastination [$\Delta R^2\ R^2 2\text{-}\ R^2 1) = .007$ p = .369]. The beta coefficients of the three interaction values created are likewise not statistically significant (β = .050 p = .364; β = −.029 p = .631; β = −.055 p = .364). Being in different grade levels does not cause a significant difference in the relationship between their MA and academic procrastination behavior. The effect sizes (Cohen f^2) were .216 for the first model (*VIF* = 1.216, tolerance = .822) and .227 for the second model (*VIF* = 1.227, tolerance = .815). Both effect sizes indicate medium effect.

Discussion, Conclusion, and Recommendations

The results indicate that university students tend to have a lower than medium level of academic procrastination. This is similar to the results of Aydın and Koçak's (2016) research also conducted on university students. Ilter

(2019) worked with vocational school students and discovered a low to moderate level of academic procrastination behavior. Coşar (2019) and Vural and Gündüz (2019), in their research with pre-service teachers, found that the students demonstrated above average and moderate levels of academic procrastination behavior, respectively.

This study found that university students had a higher than moderate level of MA. Aykut et al. (2016) and Deniz et al. (2014), in their studies in which they investigated pre-service teachers'MA, similar to this study, found that students had a higher than moderate level and high level of MA, respectively. From the sub-dimensions of MA, OA has the highest mean score, and JA has the lowest mean score. Organizational awareness refers to the steps of planning in the learning or problem-solving process and implementing this plan; JA refers to the evaluation of alternative methods after completing the process (Fırat-Durdukoca, 2013). Accordingly, one can derive that the participant students are more interested in the learning or problem-solving process and give relatively less importance to the evaluation stage after the completion of the process.

There was a negative, moderate, and statistically significant relationship found between academic procrastination behavior and MA. The study results of Bedel (2017) and Wong (2012), who investigated a similar relationship, support the findings of this study, whereas the findings of Vural and Gündüz (2019) and Çırıkçı (2016) differ. Vural and Gündüz (2019) and Çıkrıkçı (2016) identified a low level of correlation between the two variables. Considering the relationships in the context of sub-dimensions, there was a moderate relationship between self-awareness and academic procrastination, and there were low-level statistically significant relationships between OA and JA and academic procrastination. Personal awareness refers to what individuals do to perceive and solve a subject or problem that is related to them. Accordingly, one can interpret that students can significantly reduce academic procrastination behavior if they recognize their strengths and weaknesses, become aware of the conditions under which they can learn more easily, know what they need in problem-solving, and create their own strategies (Fırat-Durdukoca, 2013).

Personal awareness and OA, which are sub-dimensions of MA, significantly predict academic procrastination behavior. Judgmental awareness does not significantly contribute to the model. Personal awareness alone explains about 16% of the variance in academic procrastination; when considered together with OA, it explains 18.5% of the variance. Metacognitive awareness is a significant variable in predicting academic procrastination behavior when considered as a whole. The MA variable explains 17.8% of the variance in academic procrastination behavior. There is a statistically significant decrease in academic procrastination behavior as MA increases. Vural and Gündüz (2019) calculated the explanatory power of cognitive awareness for the variance in academic procrastination behavior as 27%, whereas Bedel (2017) calculated the explanatory power of metacognitive regulation and mindfulness for the variance in academic procrastination behavior as 37%. The models are statistically significant in both studies. According to the current study, although the percentages of explanation differ, they show mutually supportive results in terms of finding a significant relationship between the two variables. Bytamar et al. (2017) stated that metacognitive beliefs about academic procrastination behavior significantly predict academic procrastination, and this variable had an explanatory power of 5% of the variance in academic procrastination. Considering that metacognitive beliefs about academic procrastination are related to general metacognitive awareness, one can say that the results of Bytamar et al. (2017) and this study support each other. In his experimental research, Sheykholeslami (2017) concluded that cognitive and metacognitive strategies reduce academic procrastination behavior in students with low academic achievement. The results herein also provide additional evidence for the significant relationship between the two variables.

The gender and grade level variables did not play a moderator role in the relationship between MA and academic procrastination behavior. Based on these findings, the following recommendations were made:

1. As students' JA has a low average compared with other dimensions of MA, researchers can conduct informative studies on students to evaluate the process after the problem-solving and learning processes.
2. There is a significant relationship between MA and academic procrastination, and MA is a variable that significantly predicts academic procrastination. Because academic procrastination decreases as MA increases, researchers can conduct studies to increase MA.
3. Researchers can investigate the variables that play a moderator role in the relationship between MA and academic procrastination.

Author Contribution Rate

This study was completed by one researcher.

Statement of Interest

There is no conflict of interest in this study.

Statement of Research and Publication Ethics

I declare that this study complies with research and publication ethics.

Ethics Committee Approval

This study was conducted based on the permission obtained from the Tokat Gaziosmanpaşa University Social and Human Sciences Research Ethics Committee dated 02.03.2020, session number 02, and decision number 08.

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Investigation of the Individual Characteristics that Predict Academic Resilience

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Investigation of the Individual Characteristics that Predict Academic Resilience

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Abstract

The percentage of students with lower academic achievement than their peers due to their socio-economical disadvantages is globally accepted as an indicator of inequality. Some students, despite their disadvantages, are as successful as their advantaged peers. The family and individual characteristics and academic experiences of these students, who are referred to as academically resilient, provide useful information to the institutions that work to increase the academic success levels of other disadvantaged students. Accordingly, this study aims to determine the individual characteristics of academically resilient students, focusing on the PISA Turkey results. In line with the OECD criteria, an equal number of academically resilient (N=214) and academically disadvantaged (N=214) students participated in the study. Students whose economic, social, and cultural index values are amongst the bottom 25% were considered to be disadvantaged, and those who performed at level 3 and above in reading proficiency were regarded to be successful. Eighteen individual characteristics measured within the scope of PISA research were included in the study as independent variables. A binary logistic regression analysis was used in the analysis of the data. The regression model created in line with the findings predicted 67 percent of the variance in academic resilience and made an accurate classification of 85 percent. In order of their power, the predictors of academic resilience are grade repetition, use of metacognitive learning strategies (understanding, summarizing, evaluating credibility), reading for enjoyment, attitude towards academic competition, self-efficacy, and the desired occupation.

Keywords: Academic Resilience, PISA, Individual Characteristics

Introduction

Inequality in accessing education is a common problem, especially in low-income countries, despite new and improved capabilities. Inequality begins within the family and persists in the educational environment, but depending on the quality of the education provided, it may partially decrease in time. Factors such as living in a low socio-economic status household, inability to study at home, health problems, being an immigrant, and insufficient school opportunities lead to and deepen inequality in education (Jacob and Holsinger, 2008; UNESCO, 2018; World Bank, 2018). One of the main goals of education systems is to prevent the emergence of differences in the academic achievement levels of students due to the reasons listed (Niemi, 2021). Negative conditions that arise for different reasons do not affect all students equally. Students called "academically resilient" are those who can be as successful as their advantaged peers under disadvantaged conditions. The cognitive and affective characteristics of these students and the conditions that lead them to succeed under negative conditions have been a topic of interest for a long time (Martin & Marsh, 2006). The OECD uses the proportion of academically resilient students as an educational inequality indicator. The higher the number of academically resilient students is in a country, the better educational equity is achieved (OECD, 2018a). PISA, in addition to academic tests, encompasses measurement tools to determine the individual characteristics of academically resilient students in a multi-dimensional manner. Reports on academic resilience are published by the OECD based on the PISA results. In these reports, inter-country comparisons are made and findings on educational inequality are presented. Turkey is among countries in which the number of academically resilient students is low and therefore, educational inequality is prevalent (OECD, 2018a; Agasisti et al., 2018). Identifying the individual characteristics of academically resilient students that lead them to success provides useful information that will help reduce educational inequality. Studies that investigated the individual

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characteristics of academically resilient students based on PISA Turkey data (Morsunbul & Yazar, 2021; Yavuz, 2015; Yüce, 2019) utilized a few variables, while in this study, a broader perspective was adopted. It is thought that the findings of this study will serve as a guide for educational researchers and practitioners. This study aims to "determine the individual characteristics that predict the academic resilience levels of high school students." Accordingly, answers were sought to the following research questions: (1) What distinguishing personal characteristics distinguish academically resilient high school students from low socioeconomic backgrounds? (2) How predictive of academic success levels are individual characteristics of high school students from low socioeconomic backgrounds?

Literature Review

Academic Resilience

Resilience is defined as the ability of an individual to successfully overcome adversity brought about by negative life situations (Chung, 2008). Resilience is a positive factor that helps with adaptation rather than a personality trait; it refers to exposure to and coping with difficulties and the environment's support to cope with them (Lutha & Cicchetti, 2000). Resilience can be a topic of discussion when an individual faces difficulty and successfully overcomes and copes with it. The difficulty mentioned in the definition is the environmental conditions that threaten or prevent the fulfillment of developmental tasks at respective ages (Schoon, 2006). Different types of resilience are named in accordance with the areas on which they focus, as in psychological resilience (Fletcher & Sarkar, 2013), academic resilience (Martin & Marsh, 2006), physical resilience (Whitson, Duan-Porter, Schmader, Morey, Cohen, & Colón-Emeric, 2016), and emotional resilience (Grant & Kinman, 2014). In particular, the studies on resilience in the psychology literature, which constitutes the basis of studies on other types of resilience, focus on the findings obtained from traumatized and distressed individuals and risk groups who perform better than expected. In the psychology literature, the first studies on resilience, which focused on psychological issues, date back to the mid-1970s (Lutha, & Cicchetti, 2000).

On the other hand, the first studies on academic resilience, which focused on the experiences of immigrant children, date back to 1991 (Waxman, Gray, & Padron, 2003). There are two definitions of academic resilience in the literature due to the difference in classifying the problems that negatively affect students' academic achievement levels. Academic resilience is defined by the OECD (2018a, p.6) as "students who succeed in school despite coming from a socioeconomically disadvantaged background." Similarly, Agasisti and Longobardi (2014) defined academically resilient students as those who come from a disadvantaged socio-economic background and yet achieve a relatively high level of academic achievement. As can be seen in these definitions, a low socio-economic background is regarded as the main obstacle to academic success. Martin (2013) defined academic resilience as students' capacity to overcome problems that prevent academic development.

Similarly, Cassidy (2016) defined academic resilience as the increased likelihood of educational success despite adversity. According to Wang, Haertel, and Walberg (1994), academic resilience is the heightened likelihood of success in school and other life accomplishments despite environmental adversities brought about by early traits, conditions, and experiences. These three definitions represent varying opinions on the barriers to academic success. It can be seen that in these definitions, different factors such as the status of the student group (low SES, being an immigrant or minority, etc.) and negative conditions (poverty, the situation at home, studying environment, number of siblings, having a single parent, school facilities) were taken into consideration (Waxman et al., 2003).

Individual Characteristics of Academically Resilient Students

A number of variables were found in studies on the distinguishing personal characteristics of academically resilient students. In a compilation study by Gafoor and Kottalil (2011), the personal characteristics of academically resilient students were identified and grouped under four dimensions: within-child protective factors (motivational factors, self-beliefs, cognitive factors, meta-cognitive factors, emotional relationships, social skills), within-family protective factors (parental expectations, parental involvement, total family environment), within-school protective factors (school organizational factors, school atmosphere, teacher behavior, instructional factors, peer behavior), and within-community protective factors (personnel support, community resources, cultural support).

The PISA test, performed by the OECD, offers a broad framework of the individual characteristics that improve academic resilience. When they are provided with better educational opportunities, the academic achievement levels of students from low socio-economic backgrounds increase more than those of other similar disadvantaged students. Good educational opportunities include rich teaching materials and equipment, various

extra-curricular and social activities, and attentive and supportive school administration. The teaching strategies employed by teachers (student-centered, feedback-intensive, questioning) and the time students spend at school for classes also affect learning (Agasisti & Longobardi, 2014; Agasisti & Longobardi, 2017; Agasisti et al, 2018; OECD, 2011; García- García-Crespo et al., 2019; OECD, 2018a; Sandoval-Hernandez, & Cortés, 2012). A student who is academically resilient has a strong sense of belonging to their school (Aydner & Kalender, 2015). Despite coming from low socioeconomic backgrounds, academically resilient students have better access to learning environments, computers and the Internet, other academic resources, and reading materials than other disadvantaged students (OECD, 2018a). Also, parents' education levels of academically resilient students are higher than those of other disadvantaged students (Karklina, 2012). Having received pre-school education fosters better academic achievement at later ages (Cheung et al., 2014). Academic resilience is regarded as an alterable attribute affecting students' school success rather than a fixed character trait (Waxman et al., 2003). Numerous factors have been identified in studies carried out to investigate the individual characteristics that help students achieve academic resilience. Academically resilient students have higher expectations for their study period (Cheung et al., 2014; Erberer et al., 2015; Sandoval-Hernández, & Bialowolski, 2016), allocate more time for homework (Sandoval, 2016), have better attitudes toward learning (Frempong et al., 2016; OECD, 2011), and are more self-confident García-Crespo et al., 2019; Sandoval-Hernandez, & Cortés, 2012;), self-efficacious (Cheung, 2017), motivated (Agasisti, & Longobardi, 2014; Cakir, 2011; Sandoval-Hernandez, & Cortés, 2012), and better pre-informed (Cheung, 2017).

Identifying Academically Resilient Students

A specific level of disadvantage and success must be sought in identifying academically resilient students. PISA and TIMMS tests consider economic, social, and cultural variables in determining disadvantaged groups. The PISA index of economic, social, and cultural status (ESCS) takes into account parental occupation and the highest level of parental education, as well as possessions related to family wealth and home educational resources (educational materials, number of books, cars, computers, musical instruments, etc.) (OECD, 2018b). The home educational resources (HER) index developed by TIMMS takes into account the father's and mother's highest educational levels, the number of books at home, and home possessions (Broer, Bai, & Fonseca, 2019). While students whose PISA ESCS index values are amongst the bottom 25% are considered to be disadvantaged (OECD, 2018b), TIMMS divides students according to their HER index scores into three levels: high, medium, and low, and those who are at the low level are considered to be disadvantaged. The characteristics of the group in which the study is carried out are another pivotal variable in the identification of disadvantaged students. In relevant studies, being an immigrant, minority, or disabled is regarded as a criterion to be included in the disadvantaged students' group (Anagnostaki, Pavlopoulos, Obradović, Masten, & Motti-Stefanidi, 2016; Freeman, Stoch, Chan, & Hutchinson, 2004; Perez, Espinoza, Ramos, Coronado, & Cortes, 2009).

The second criterion in determining academically resilient students is the percentile of those who will be considered successful. Students who achieve a level 3 or higher in mathematics, science, or reading are considered successful by the OECD (2018a). Agasisti et al. (2018) emphasized that for students to be successful, they must perform at level 3 or above in all three areas. In addition, values such as the top 20, 25, and 33 percent are taken as the cut-off values. In their studies on TIMSS scores, Cheung et al. (2014), Agasisti et al. (2018), Erberer et al. (2015), and Sandoval-Hernández and Bialowolski (2016) adopted a cutoff value in determining successful students.

Characteristics Taken into Consideration

Within the scope of the PISA test, many different types of data on family, school, and individual characteristics are collected. In this study, the dimension of individual characteristics was taken into consideration, and family and school dimensions were excluded. Descriptive information about the variables is as follows:

*Metacognitive Knowledge***:** Metacognitive knowledge is a higher-order thinking process that includes active control over cognitive processes. Metacognitive knowledge helps learners to plan and allocate learning resources, monitor their current knowledge and skill levels, and evaluate their learning level during problem-solving or knowledge acquisition (OECD, 2014). In PISA 2018, three metacognitive strategies were evaluated in the reading field: summarizing and understanding a text, memorizing, and assessing the quality and credibility of sources included in the texts. While the first two strategies were evaluated in previous years, the third strategy was added in 2018 to emphasize the credibility of digital means of communication (OECD, 2018b).

*Expectations for the future***:** The students' expectations were evaluated by their desired occupations. The more prestigious the occupations, the higher the scores they contributed. (OECD, 2018b).

*Reading for enjoyment***:** This refers to how much the student enjoys reading (OECD, 2018b).

Attitudes towards learning at School: refers to students' attitudes towards education and training at school (OECD, 2018b).

Competitiveness: refers to the students' ability to cope with the competitive learning environment (OECD, 2018b).

Motivation to master tasks: refers to students' motivation to perform academic tasks (OECD, 2018b).

Fear of failure: refers to students' fear of academic failure. Although fear of failure motivates some students to study harder, it usually negatively affects students' academic achievement levels (Martin, 2002).

Subjective well-being: **r**efers to an individual's overall satisfaction with their lives as well as their perception of their feelings about it (Diener & Ryan, 2009). Students with higher levels of subjective well-being may be more successful academically (Nickerson, Diener, & Schwarz, 2011)

Self-efficacy: **r**efers to one's belief in one's own capacity to fulfill certain tasks in the face of problems (Bandura, 1987). Self-efficacy is important in developing academic resilience (Rachmawati, Setyosari, Handarini, & Hambali, 2021).

Mastery goal orientation: Refers to the aspiration and effort towards achieving learning goals, perpetuated by intrinsic motivation (Pintrich, 2000).

Sense of belonging at school: Refers to students' perceiving and experiencing respect, acceptance, and embracement. Thanks to these feelings, students feel a sense of belonging to the school (Strayhorn, 2018).

Cognitive flexibility: **r**efers to the use of knowledge and experience to develop, adjust, and combine ways to cope with novel and different situations (Spiro, 1988).

Grade repetition: refers to whether the student has repeated a grade or not.

Method

Research Model

In this study, the relational screening model, which aims to determine the presence of two or more variables and to specify the relationships between the variables, was adopted. The relational screening model is used to identify the direction and strength of the relationship between two or more variables (Creswell & Creswell, 2017). A binary logistic regression analysis was performed on PISA data to determine academically resilient students' individual characteristics.

Participants

PISA assesses 15-year-old students who receive face-to-face education, regardless of the type of educational establishment in which they are enrolled, their socio-economic levels, and the country (PISA, 2018b). As a part of the PISA test performed by the OECD, data on students, families, teachers, school administrators, and schools is also collected. The data obtained from the PISA test, takenby selected students from each country, is used to draw up a general report, and the OECD databases are available to researchers for detailed analysis. 189 schools and 6855 students from Turkey participated in the 2018 PISA test. The academically resilient students were identified in line with the criteria set by the OECD. Accordingly, students whose economic, social, and cultural index scores are amongst the bottom 25% were selected. This group is made up of Turkish students who are classified as socio-economically and culturally disadvantaged. PISA tests evaluate students in three academic areas by means of detailed questions. Since the major domain was reading literacy in PISA 2018, the scores obtained from reading questions were taken into account in the selection of successful students in order to include the variables related to reading in the data analysis. Of the students whose ESCS scores are amongst the bottom 25%, those who performed at level 3 and above in reading proficiency were included in the study. It was accepted that 214 students (3.1%) who met both criteria were academically resilient. For comparison purposes, 214 students who are among the bottom 25% in terms of ESCS scores but performed below level 3 in reading comprehension were also included in the study. Descriptive information about the students included in the study is given in Table 1.

Table 1: Descriptive information about students included in the study

		Not Resilient		Resilient		Total	
		F	%	F	%	F	%
Gender	Boy	118	55,1	79	36,9	197	46,0
	Girl	96	44,9	135	63,1	231	54,0
School Type	General Secondary Education	96	44,9	182	85,0	274	64,9
	Vocational and Technical Secondary Education	118	55,1	32	15,0	150	35,0
Total		214	100,0	214	100,0	428	100,0

Data Collection Tools

The researchers developed measurement tools whose validity and reliability were proven and were used in collecting PISA data. The variables of grade repetition and gender are binary categorical. The number of items, the answer scale, and sample questions regarding other variables are given in Table 2. In the PISA database, standardized total scores are obtained from both the raw answers given to the scale items and the sum of the answers given to the items. In this study, these standard scores were used, and as per the PISA technical report, the scales were accepted to be valid and reliable, and no further analysis was performed on the results.

Table 2: Descriptive information about variables

Variables (PISA Codes)	Items (N)	Scale	Sample Item
Understanding and remembering (UNDREM)	6	6-point (Not useful at all- Very useful)	I quickly read through the text twice.
Summarising (METASUM)	5	6-point ert (Not useful at all- Very useful)	I try to copy out accurately as many sentences as possible.
Assessing credibility (METASPAM)	5	6-point (Not useful at all Very useful)	Check the sender's email address
Expected occupational status (BSMJ)		Open ended	What kind of job do you expect to have when you areabout 30 years old?
Joy/Like reading (JOYREAD)	5	4-point (Strongly disagree- Strongly agree)	I read only if I have to.
Attitudes towards learning activities (ATTLNACT)	3	4-point (Strongly disagree- Strongly agree)	Trying hard at school is important.
Competitiveness (COMPETE)	3	4-point (Strongly disagree- Strongly agree)	I enjoy working in situations involving competition with others.
Work mastery (WORKMAST)	4	4-point (Strongly disagree- Strongly agree)	I find satisfaction in working as hard as I can.
Fear of failure (GFOFAIL)	3	4-point (Strongly disagree- Strongly agree)	When I am failing, I worry about what others think of me.
Subjective well-being (SWBP)	9	4-point (Asla- Hep)	Happy
Self Efficacy (RESILIENCE)	5	4-point (Strongly disagree- Strongly agree)	I usually manage one way or another. 01 02
Mastery goal orientation (MASTGOAL)	3	5-point (Not at all true of me-Extremely true of me)	My goal is to learn as much as possible.
Belonging to school (BELONG)	6	4-point (Strongly agree- Strongly disagree)	I make friends easily at school.
Cognitive flexibility (COGFLEX)	6	5-point (Very much like me-Not at all like me)	I can deal with unusual situations.

Source: (OECD, 2018b)

Data Analysis

Percentage and frequency values were calculated for the descriptive characteristics of the students included in the study. A binary logistic regression analysis was performed to identify academically resilient students' individual characteristics. Binary logistic regression analysis is performed when the dependent variable is binary categorical and the independent variables are interval, ordinal, or categorical. In this study, gender and grade repetition variables were categorical, metacognitive knowledge was ordinal, and other variables were interval. The low number of assumptions in logistic regression analysis also makes it easier for researchers to perform the analysis. In logistic regression analysis, there should be no extreme data values and or multicollinearity between independent variables (Hilbe, 2009).

Results

In binary logistic regression analysis, there should be no extreme data values or multicollinearity between independent variables. Tolerance and VIF values were calculated to find out whether there was multicollinearity between the variables. To be suitable for the analysis, the tolerance value of the variables should be below 1 and the VIF value should be below 10 (Hilbe, 2009). The VIF and tolerance values were found to be below the respective cut-off values, indicating no multicollinearity between the variables. In this study, standardized residual values were calculated through casewise diagnostics to detect outliers. In this study, standardized residual values were calculated through casewise diagnostics to identify any outliers. Standardized residual values above 3 were accepted as extreme. No outliers were detected in this study. The data analysis started after the assumptions were provided.

Table 3: The result of the binary logistic regression analysis performed to determine the individual characteristics that predict academic resilience

Independent variables	B Coeff.	SE	Wald	df	Sig.	Exp(B) Odss Ratio	95% C.I.for EXP(B) Lower	Upper
Grade Repetition (Yes)	3,445	,845	16,640	1	,000	31,348	5,988	164,098
Expected Occupational Status	,029	,008	11,775	1	,001	1,029	1,012	1,046
Understanding and Remembering	,634	,175	13,087	1	,000	1,886	1,337	2,659
Summarising	,900	,180	25,091	1	,000	2,460	1,730	3,499
Assessing Credibility	,998	,157	40,262	1	,000	2,714	1,994	3,694
Joy/Like reading	,487	,187	6,782	1	,009	1,627	1,128	2,346
Attitudes Towards Learning Activities	,055	,144	,145	1	,703	1,056	,797	1,401
Competitiveness	,479	,136	12,349	1	,000	1,614	1,236	2,108
Work Mastery	-,116	,183	,406	1	,524	,890	,622	1,273
Fear of Failure	-,098	,156	,399	1	,527	,906	,668	1,230
Subjective Well-Being	-,249	,144	3,002	1	,083	,780	,588	1,033
Self Efficacy	,424	,162	6,861	1	,009	1,528	1,113	2,098
Mastery Goal Orientation	-,240	,168	2,035	1	,154	,786	,565	1,094
Cognitive Flexibility	-,190	,174	1,183	1	,277	,827	,588	1,164
Belonging to School	,209	,159	1,738	1	,187	1,233	,903	1,683
Gender (Girl)	,353	,327	1,166	1	,280	1,424	,750	2,703
Constant	-5,967	1,105	29,174	1	,000	,003		
Nagelkerke R^2=.667, Omnibus Chi-square=330,849, df=16, p=.000, Hosmer ve Lemeshow= p>.05								

This study included 16 individual characteristics evaluated within the scope of PISA as independent variables. The regression model that emerged as a result of the binary logistic regression analysis performed to determine the impact of the independent variables on the participants' academic resilience levels was found to be statistically significant (Omnibus X2 (16) = 330,849, p <.05, Hosmer and Lemeshow = p>.05). The independent variables of the study predict 67% of the variance in students' academic resilience levels. Among the independent variables, grade repetition, desired occupation, understanding, summarizing, assessing credibility, reading for enjoyment, competitiveness, and self-efficacy were significant (p<0.05). On the other hand, the variables of attitudes towards learning at school, motivation to master tasks, fear of failure, subjective well-being, cognitive flexibility, sense of belonging at school, mastery goal orientation, and gender were found to be insignificant (p>0.05). The statistically significant variables in the order of their predictive powers are grade

repetition (3.445), understanding (.998), summarizing (.900), assessing credibility (.634), reading for enjoyment (.487), competitiveness (.479), self-efficacy (.424), and desired occupation (.029). Academically resilient students are those who have not repeated a grade, have high hopes for the future, make use of metacognitive strategies, enjoy reading, enjoy competition, and have high self-efficacy (Table 3).

Findings show that grade repetition is an important determinant of academic resilience. Grade repetition is 3134 percent more common among non-academically resilient students, according to the exp(B) value. Students who do not repeat a grade have a 97% chance of being academically resilient, whereas it is only 3% for those who do.

It was observed that the use of metacognitive knowledge in reading is a significant predictor of academic resilience. The same can be held to be valid for all three sub-dimensions that constitute metacognitive knowledge. The Exp(B) value shows that the chance of being academically resilient is 65% for those with high levels of reading-remembering, 71% for those with high levels of summarizing, and 73% for those with high levels of assessing credibility.

It is seen that the self-efficacy levels of a student are an important variable in predicting academic resilience. Competitive students with high self-efficacy levels are 19% more likely to have academic resilient than non-competitive students. Students with high self-efficacy are 65% likely to have academic resilience, while those with low levels of self-efficacy are only 35% likely to be academically resilient.

Findings show that the level of competitiveness is a partially important predictor of academic resilience. The Exp(B) value demonstrates that competitive students are 15% more likely to be academically resilient. While students who avoid or do not like competition are 60% more likely to be academically resilient, those who avoid or do not like competition are only 40% likely to have academic resilience.

It is seen that the self-efficacy levels of a student are an important variable in predicting academic resilience. The Exp(B) value shows that students with high self-efficacy levels are 19% more likely to have academic resilience. Students with high self-efficacy are 65% likely to have academic resilience, while those with low levels of self-efficacy are only 35% likely to be academically resilient.

Although the desired occupation is a significant predictor, it is not found to be significantly discriminative. Exp(B) value shows that those aiming for high-level jobs are 3% more likely to have academic resilience. Those aiming for a high-level job have a 51% chance of being academically resilient, while those aiming for a low-level job have a 49% chance.

Table 4: Classification table of the binary logistic regression analysis performed to identify the individual characteristics that predict academic resilience

Observed	Predicted		Percentage Correct
	Not Resilient	Resilient	
Not Resilient	181	33	84,6
Resilient	28	184	86,8
Overall Percentage			85,7

According to the classification table, the proposed regression model correctly classified the students who were not academically resilient by 84.6% and the students who were academically resilient by 86.7%. The overall accuracy percentage of the classification is 85.7. An accuracy of over 80% in both dimensions shows that the model produced very accurate results (Table 4).

Discussion

Sixteen individual characteristics evaluated within the scope of PISA were included as independent variables in the regression model developed to identify the individual characteristics predicting academic resilience in high school students. It was concluded that eight of these variables were significant predictors and predicted 67% of the variance in academic resilience. The high predictive value manifests the strong explanatory power of the independent variables. Another indicator that the proposed model is extremely effective in predicting students' academic resilience levels is that it has a classification accuracy of over 85%. This demonstrates that the proposed model can classify students as academically resilient or academically weak based on their individual characteristics.

The predictors of academic resilience, in order of their power, are grade repetition, use of metacognitive learning strategies (understanding, summarizing, evaluating credibility), reading for enjoyment, attitude towards academic competition, self-efficacy, and the desired occupation. The strongest predictor of academic resilience is whether the student has repeated a grade or not. Not having repeated a grade in primary and/or secondary school significantly increases the possibility of being academically resilient. Grade repetition is applied to students who have academic difficulties. According to PISA data, 12% of all students who took the test and 14.5% of Turkish students who took the test stated that they repeated grade once. This rate is 20% for students who are socio-economically disadvantaged and 7% for pupils who are advantaged (OECD, 2014). Instead of making them repeat a grade, socioeconomically disadvantaged and failing pupils can be encouraged to advance in academic levels alongside their age group by engaging in extracurricular activities to address their learning disabilities. The findings of this study also show that grade repetition negatively affects academic achievement. This is shown by the fact that students who don't have to repeat a grade are more likely to be strong-willed. But it should also be taken into account that students who don't do well in school have to repeat a year.
Making use of metacognitive learning strategies is second to grade repetition in predicting academic resilience. Although metacognitive learning strategies consisting of three sub-dimensions (understanding, summarizing, and assessing credibility) differ within themselves, all three are among the top predictors of academic resilience. The use of metacognitive strategies is an important variable predicting academic success (Vrugt & Oort, 2008; Young & Fry, 2008). Disadvantaged students who employ these strategies effectively are more successful than their peers from similar backgrounds. Metacognitive strategies are used by people who are aware of how they learn and try to take control of it. These students can plan their own learning well and do it on purpose. So, they do better in school because they know how to study effectively. It can be said that teaching disadvantaged students how to use meta-cognitive strategies will help them do better in school. In their study, Rashidzade and Hashemi (2019) concluded that the use of metacognitive strategies improves academic resilience.

It was found that reading for enjoyment is another significant predictor of academic resilience. As the attitude towards reading books is a variable that predicts academic success (Bastug, 2014; Kush, Watkins & Brookhart, 2005), it is natural that it is also a predictor of academic resilience. The OECD also takes into consideration the number of books at home while identifying disadvantaged students. Although the number of books in disadvantaged students' homes is low, academically resilient students have more books in their homes than non-academically resilient students (OECD, 2018). Accordingly, it can be concluded that children who grow up in homes where they have access to books develop a positive attitude towards reading. The findings of this study are similar to those in other relevant studies in the literature. In a study carried out by García-Crespo, Galián, Fernández-Alonso and Muñiz, (2019) on PIRLS exam results, reading for enjoyment was found to be a predictor of academic resilience. In the study conducted by Kasap, Doğan and Koçak (2021), it was concluded that reading for enjoyment is one of the most important predictors of academic success.

Attitude towards academic competition is one of the important predictors of academic resilience. Students who have positive attitudes towards and do not refrain from competition and study harder in a competitive environment are more likely to be academically resilient. Although the Turkish education system draws on a student-centered teaching approach encompassing cooperative learning guided by curricula and teacher instruction (Kısa, Uysal & Kavak, 2020; MEB, 2018), the existence of high school and university entrance exams does not change the fact that there is competition among students and it impacts the educational environment. The existence of quality differences between different high schools and universities leads to students competing for a handful of educational institutions. Therefore, students who are in competition with their peers and perform better in a competitive environment can be more successful academically.

Self-efficacy, another essential predictor of academic resilience, refers to individuals' belief in t their self-fulfilling certain tasks in the face of problems (Bandura, 1987). Students with high levels of self-efficacy are also more successful academically (Caprara, Vecchione, Alessandri, Gerbino & Barbaranelli, 2011; Yusuf, 2011). Individuals with high self-efficacy try to cope with difficult situations instead of avoiding them and eliminate factors that lead to failure more easily (Bandura, 2010). Accordingly, it can be held that students with high self-efficacy are also academically resilient. A student can have high self-efficacy in a subject if he or she is sure that he or she can do well in that subject. Self-efficacy will improve when people talk about doing well in school and being successful in the world around them. On the other hand, a person's sense of self-efficacy may go down if the opposite is true (Bandura, 2010). Studies that help students from bad situations feel better about themselves might help them do as well in school as their peers from better situations. The findings of this study are parallel to those of García-Crespo, Galián, Fernández-Alonso, Muñiz, (2019) and Salvo-Garrido, Vargas, Urra, Gálvez-Nieto and Miranda-Zapata, (2019).

Among the eight variables that predict academic resilience, the desired occupation variable is the one with the lowest predictive power. Aspiration for high-level jobs increases the students' academic resilience levels. Also, there is a linear relationship between the level of realism regarding the desired profession and the level of academic resilience (Krammer, Sommer & Arendasy, 2016). Having decided on a profession to do in the future means positive expectations about the future, which, in turn, means better academic resilience (Sandoval-Hernández & Białowolski, 2016). At the elementary, middle, and high school levels, seeking a good job is within the range of a far-off goal. Because of this, there won't be much of a link between how well you do in school and what you want to do with your life. Avcı (Avcı, 2013) talks about how important it is to set smaller goals for long-term goals in order to strengthen this connection.

It has been concluded in this study that attitudes towards learning at school, motivation to master academic tasks, fear of failure, subjective well-being and cognitive flexibility levels, sense of belonging at school, mastery goal orientation, and gender are not significant predictors of academic resilience. Attitude towards learning at school refers to students' positive or negative views on academic activities at the respective educational institution. Although it has been concluded in this study that attitude towards learning at school does not predict academic resilience, this finding differs from the general consensus in the literature. Having a positive attitude towards learning at school contributes to the increase in academic success as well (Fakeye, 2010; Kpolovie, Joe, & Okoto, 2014; Moè, Pazzaglia, Tressoldi, & Toso, 2009). In addition, having a positive attitude towards learning at school is regarded as one of the individual characteristics of academically resilient students (Borman & Rachuba, 2001; Borman & Overman, 2004). The PISA test results of the 9th-grade students are actually indicators of the education they received in primary and secondary schools. Students took into account the new educational approach they encountered in their high schools while answering the questions related to attitude, which may be the reason why attitude towards learning at school was not found to be a significant predictor of academic resilience. At the same time, the fact that attitudes in the academic environment differ by course rather than in general may have contributed to this result.

When the motivation to master academic tasks is combined with academic resilience, the likelihood of high academic achievement increases (Martin, 2002). High motivation to master academic tasks impacts the level of academic resilience as well. In this study, however, a contrary finding has been obtained. In a study carried out by Gamazo and Martínez-Abad (2020) on PISA data, it was concluded that motivation to master academic tasks is a predictor of academic success.

As far as fear of failure is concerned, it is more likely that this fear will lead students to failure caused by self-doubt than to success. So, it can be held that fear of failure does not contribute to academic resilience (Martin, 2002; Martin, & Marsh, 2008). This is especially valid for students from low socio-economic backgrounds (Nsiah, 2017). It has been concluded in this study that fear of failure is not a significant predictor of academic resilience. The lack of any sanctions or negative consequences for failing the PISA exam could be the reason why there is no correlation between anxiety and academic success.

Subjective well-being refers to happiness, satisfaction with life, and the presence of positive and low negative affect (Ryan, & Deci, 2001). Differing from the findings of this study, Eva, Parameitha, Farah and Nurfitriana (2020) revealed that there is a relationship between subjective well-being and academic resilience. Also, there is a significant relationship between subjective well-being and academic achievement (Chattu et al., 2020; Tong, Li, & Shu, 2021). Success on the PISA test shows long-term academic knowledge, but subjective well-being shows what's going on right now. Because the PISA test is given in the ninth grade in Turkey, there may not be a link between the two, but the results show what the students learned in secondary school. Different levels of subjective well-being may have been caused by things like students not being able to adjust to their new school or not being able to make friends.

Sense of belonging at school refers to the students' seeing themselves as a part of their school and classroom and feeling respect, acceptance, and embracement (St-Amand, Girard, & Smith, 2017; Strayhorn, 2018). Different from the results of this study, it was found in different studies (García-Crespo, Galián, Fernández-Alonso & Muñiz, 2019, García-Crespo, Fernández-Alonso, & Muñiz, 2021) that there is a relationship between a sense of belonging at school and academic resilience. Students who exhibit a high level of affiliation with their schools are more academically resilient. It is possible that since the students included in this study are only 9th-graders, they have not yet had experiences that would make them feel like they belong to their schools, regardless of their academic achievement levels.

Cognitive flexibility refers to the use of knowledge and experience to develop, adjust, and combine ways to cope with novel and different situations. Students with improved cognitive flexibility easily adapt to new

conditions when they encounter difficulties (Spiro, 1988). In studies carried out by Canas, Fajardo and Salmeron (2006) and Yavuz and Kutlu (2016), similarly with this study, it was found that there was no difference in terms of cognitive flexibility between academically resilient and non-academically resilient students. The researchers justified this finding, which is not compatible with the consensus in the literature, with cultural differences.

Mastery goal orientation is the aspiration and effort towards achieving learning goals and is perpetuated by intrinsic motivation (Pintrich, 2000). Goal orientation affects students' learning and academic achievement (Zimmerman, & Kitsantas, 1997). There is a moderate relationship between goal orientation and academic achievement (Gul & Shehzad, 2012; Hejazi, Lavasani, Amani, & Was, 2012). No research has been found in the literature that investigates the relationship between mastery goal orientation and academic resilience.

Finally, it has been concluded that gender is not a significant predictor of academic resilience. This finding is also consistent with the findings of the study carried out by Martin and Marsh (2008). There are studies in the literature that find that females' academic resilience levels are higher (Yavuz & Kutlu, 2016). In their study carried out with students from five different Asian countries, Sandoval-Hernández and Białowolski (2016) stated that academic resilience did not vary by gender in students from four nations, with the exception of Korea, where the academic resilience levels of males were found to be higher. According to Garca-Crespo, Fernández-Alonso, and Muiz, (2021) and Agasisti et al. (2018), males have higher levels of academic resilience than females. The fact that gender is not a predictive variable for academic resilience is a very positive result for Turkish society. This result suggests that the factors that affect academic resilience positively or negatively affect boys and girls equally and that parents and teachers do not make a difference between them.

Conclusion and Recommendations

This study proposed a regression model with high explanatory and classification power that reveals the individual characteristics of academically resilient students. Grade repetition, using meta-cognitive learning strategies (understanding, summarizing, evaluating credibility), reading for enjoyment, attitude towards academic competition, self-efficacy, and the desired occupation were found to be the most powerful predictors of academic resilience among the 16 independent variables considered in the analysis. The remaining variables—including gender, a student's sense of belonging at school, their level of cognitive flexibility, their fear of failure, and their motivation to master academic tasks—were found to not be significant predictors of academic resilience.

Only the individual characteristics of the students were included in the analysis. Similar studies can be carried out with a focus on different variables related to family and school. This study was carried out with Turkish students; a comparative study can be conducted with students from different countries. The OECD (2018a) data shows that academically resilient students are approximately 50% more likely to pursue higher education than other disadvantaged students. Within the framework offered by this study, complementary activities can be carried out with students to alleviate the disadvantages of being from low socio-economic backgrounds. Terminating the application of grade repetition, which has been proven to be of no academic benefit, and closing the academic gaps through complementary activities to be carried out in the later grades will increase academic success. Also, students' skills related to the variables identified in this study, namely using metacognitive learning strategies (understanding, summarizing, and assessing credibility), reading for enjoyment, attitude towards academic competition, self-efficacy, and desired occupation, can be improved through appropriate activities. Activities oriented towards improving students' metacognitive skills are widely employed and useful practices. Deciding on an occupation to do in the future is actually about having a positive outlook toward the future. It can be said that academic resilience will increase when students are encouraged to set goals for the future and start to work towards these goals today. In improving these skills, the most important role falls to the school counselors.

Conflicts of Interest

There is no potential conflicts of interest in the study.

Ethical Approval

Ethical approval was not obtained because open access PISA data was used for the article.

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The Predictive Role of Self-Esteem, Attachment Styles, and Family of Origin Functions in Explaining Conflict Resolution in Romantic Relationships

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The Predictive Role of Self-Esteem, Attachment Styles, and Family of Origin Functions in Explaining Conflict Resolution in Romantic Relationships[1]

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Abstract

This research aims to analyze the predictive role of self-esteem, attachment styles, and family of origin functions in explaining conflict resolution in romantic relationships. A total of 265 adult participants were administered Demographics Form, Conflict Resolution Styles Scale (CRSS), Rosenberg Self-Esteem Scale (RSES), Experiences in Close Relationships-Revised (ECR-R), and Family Assessment Device (FAD). Correlational design was used to examine relationships between variables. Multiple linear regression analysis was carried out within the aim of the study. According to the results, the predictive role of attachment styles and family of origin functions on conflict resolution was significant. However, self-esteem was not found to have a significant predictive role in conflict resolution. Findings were discussed along with current literature, and theoretical implications and suggestions for future research were presented.

Keywords: Conflict resolution, Self-esteem, Attachment styles, Family of origin functions

Introduction

Conflict is a natural and vital part of life. It is a structure that enables new ideas to emerge, encourages social change, enables the definition of our group relationships, helps to form our own sense of personal identity, and a part of all forms of society (Schellenberg, 1996). Conflict is essential in every environment where people exist and establishes relationships. Therefore, it is also inevitable for adult individuals to experience conflicts in romantic relationships. Thus, it is important to understand the content of the conflict and conflict resolution strategies (Deutsch et. al., 2006).

Since conflict is an important part of both romantic and marital relationships, how spouses deal with this conflict affects the continuity and maintenance of relationships. In addition, the conflict resolution methods affect both the well-being of partners at the individual level and the perceived satisfaction from the relationship or marriage at the dyadic level (Özen, Salman-Engin, & Sakallı-Uğurlu, 2016). The strategies partners use in their romantic relationships are generally divided into four categories: (1) being able to cope with the existing conflict actively and constructively, (2) showing aggressive and destructive behavior, (3) avoiding and withdrawing from conflict, and (4) complying and obeying the wishes of the partner (Özen et al., 2016).

The self-esteem level of individuals affects the dynamics of their romantic relationships (Mruk, 2006). According to Satir (1989), how the individual chooses to deal with problems is related to the level of self-esteem. The higher the self-esteem of individuals, the less they need approval from their partners, while individuals with low self-esteem constantly seek assurances regarding the relationship. Studies have revealed that individuals with high self-esteem show more constructive relationship patterns that reduce the use of

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negative conflict resolution styles and the likelihood of breakup. In contrast, individuals with low self-esteem tend to display problematic behaviors such as excessive assurance seeking, negatively interpreting their partner's ambiguous behavior, and reducing their closeness to the partner in times of relationship conflict (Murray et. al., 1996a, 1996b). As we can see from the literature, self-esteem is one of the important factors that affect our relationships with others and significant ones.

Attachment is the tendency of people to form strong emotional bonds with others that are important to them (Bowlby, 1982). Subsequently, researchers continued to work on adult attachment. Based on Bowlby's theory of attachment, Bartholomew (1990) developed a new attachment model for adults called the four-category model of attachment. According to this model, there are four adult attachment styles based on positive or negative model of self and positive or negative model of others. These styles are secure, preoccupied, dismissing, and fearful attachment. Later on, scientists proposed dividing up the population into distinct groups based on their attachment styles. style posed some difficulties and developed the two-dimensional attachment model (Fraley et. al., 2015). According to this model, there are two dimensions in adult attachment and degrees of anxiety and avoidance determines human behavior. These two dimensions are called as "attachment related anxiety" and "attachment related avoidance" (Selçuk et. al., 2005). How people handle difficulties in romantic relationships is also influenced by their attachment style. Relational conflicts are more common and more severe for anxious people. For them, unfavorable interactions between partners are always deliberate and consistent. They don't pay attention to their partners' wants and needs, and their partners end up having to provide more care and comfort as a result.' On the other hand, avoidant individuals try to maintain a sense of independence and control. They tend to become defensive, and they experience emotional withdrawal and reduced expressions of support (Feeney & Karantzas, 2017). Securely attached individuals experience more satisfactory and successful relationships. They are better at handling conflict, less likely to view discussion as a threat, and better at recovery after conflict (Pistole & Arricale, 2003; Salvatore et al., 2011).

It is seen that both self-esteem and attachment styles are variables that are formed through family interactions in infancy and affect the relationships established in adulthood (Bowlby, 1982; Bartholomew, 1990; Mruk, 2006; Satir, 1989). Family functioning can be defined as the interactions and reactions of family members with each other, the boundaries between generations and family subsystems, and flexibility towards changes in the family (Walsh, 2012). In other words, family functioning is the ability of the family members to work together, meet the basic needs of family members, and to manage conflicts (Staccini et al., 2015). Family functioning has a multidimensional structure. This structure includes the goals of the family, the emotional support that the family provides to family members, and the incentives they show for family members to improve their well-being. At the same time, family functioning reflects the family's actions and their effective or ineffective interactions (Walsh, 2012). The way the family functions affects how individuals cope with conflict situations. According to Kerr and Bowen (1988), when a family's adaptability is exceeded, chronic anxiety increases, and family functions decline. While functional families can cope with conflict situations with a stable emotional state, non-functional families cannot overcome the problems brought about by their life cycle without experiencing them (Falcão, as cited in Oliveira et. al., 2014). According to research, children of families with unhealthy family functioning tend to use negative conflict resolution methods such as showing aggressive behavior and violence (Kabasakal, 2013). Adolescents find the opportunity to try and experience conflict resolution styles with their parents and siblings in their family conflicts. Studies show that the ways of conflict resolution styles experienced and observed within the family are similar between couples (Reese-Weber & Bartle-Haring, 1998).

Conflict and the strategies for dealing with it is a factor that is present in both romantic and marital relationships and affects the well-being of couples, the satisfaction they obtain from their relationships, and the continuity and sustainability of the relationships (Özen et al., 2016). When the studies of researchers such as Kurdek (1995), Gottman and Krokoff (1989), and Cramer (2000) are examined, it is seen that the factor that affects dyadic satisfaction is not the conflict itself, but the strategies used by partners to resolve the conflict. Related literature in Turkey (Akdağ, 2014; Bahadır, 2006; Demirci, 2004; Kaya Balkan, 2009; Zeytinoğlu, 2013) shows that the variables of conflict resolution, self-esteem, attachment styles and family of origin functions in romantic relationships are generally studied on married individuals and studied separately. The literature has not found a study that handles these variables together. For this reason, studies on conflict and conflict resolution methods in romantic relationships and its relationship with self-esteem, attachment styles, and family of origin functions are important and will enrich the literature. And the connections to be made with these variables can be a resource that mental health professionals working with relational problems can benefit from. When considered in an individual context, the analysis of the reflections of early experiences on relational conflicts can create an important awareness in the prevention of these conflicts. The goal of this study is to find out if a person's self-esteem, attachment style, and how well their first family works can predict how they handle conflicts in their romantic relationships.

Method

Design

Correlational design was used in this study, which was conducted as quantitative research. The dependent variable of the research is conflict resolution styles in romantic relationships, while its independent variables are self-esteem, attachment styles, and family of origin functions.

Participants

Participants consisted of 265 individuals aged 19 to 56 years with a mean age of 29.15 (SD =8.12) reached via online questionnaires. The instruments used in this study were turned into an online survey via Google Forms and presented to participants between January and February 2021. Convenience sampling method was used in the study. During the application, the criteria were that the participants were adults and had at least 1 romantic relationship in the past. 86 (%32.5) are males and 179 (%67.5) are females. Participants consist of married and single individuals. Some of the singles are in a relationship and some of them are not. Individuals who are currently single have, on average, one romantic relationship in their past that lasted for six months or longer. Seventy-three (27.5%) are married, while the remaining 192 (72.5%) are all unattached. There are 116 (60.4% of the total) single people who are already in a relationship, while there are 76 (39.6% of the total) single people who are not in a relationship right now (39.6). Data from 76 people who are not in a committed relationship at the present time were excluded from the analysis because of the relationship duration variable. Average relationship length is 6.03 years (SD =7.23), with a range of 0–31 years. Twenty-three participants (8.7%) had completed education beyond a bachelor's degree, eighty-five (69.8%) had completed their undergraduate degrees, and fifty-seven (21.5% had completed their graduate degrees). Table 1 shows the demographic breakdown.

Table 1. Demographics

Variables		N	%
Gender	Male	86	32.5
	Female	179	67.5
	Sum	265	100
Marital status	Married	73	27.5
	Single	192	72.5
	Sum	265	100
Educational level	None-undergraduate	23	8.7
	Undergraduate	185	69.8
	Graduate	57	21.5
	Sum	265	100
Relationship status (for singles)	In a relationship	116	60.4
	Not in a relationship	76	39.6
	Sum	192	100
Age	19-22	47	17.7
	23-28	111	41.9
	29-33	47	17.7
	34-39	25	9.4
	40+	35	13.2
	Sum	265	100
Relationship duration (year)	0-5	129	68.3
	5.1-10	28	14.8
	10.1-20	15	7.9
	20+	17	9
	Sum	189	100

Instruments

Demographics Form: The researchers formed the Demographics Form to get information about participants. The form includes statements about gender, age, marital status, duration of the relationship, and education level.

Conflict Resolution Styles Scale (CRSS): The Conflict Resolution Styles Scale (CRSS) was developed by Özen (2006) to develop a valid and reliable scale to measure couples' conflict resolution styles. The CRSS examines each partner's conflict resolution style by using four sub-dimension structure; positive conflict resolution, negative conflict resolution, subordination, and retreat (Özen, Salman-Engin, & Sakallı-Uğurlu, 2016). The CRSS consists of 25 items that are answered using a 6-point Likert-type scale. The responses given to the scale are scored between 1 = completely disagree, and 6 = completely agree. The CRSS does not give total scores. It is based on the scores of the subscales. The high scores obtained from the sub-dimensions of the scale indicate how frequently related conflict resolution style is used, and low scores indicate less use of related conflict resolution style (Özen, Salman-Engin, & Sakallı-Uğurlu, 2016).

The scale's criterion validity was assessed by the correlation between the subscales of CRSS and Kurdek's (1994) Conflict Resolution Styles Inventory (CRSI), which were reported as .75 for negative conflict resolution, .61 for positive conflict resolution, .45 for retreat, and .39 for subordination. CRSS had strong internal reliability with Cronbach's alphas .80 for the positive conflict resolution subscale, .82 for the negative conflict resolution subscale, .74 for the retreat subscale, and .73 for the subordination subscale. In this study, the reliability coefficients of the sub-dimensions of the scale are as follows: .72 for positive conflict resolution, .80 for negative conflict resolution, .76 for subordination, and .75 for retreat.

Rosenberg Self-Esteem Scale (RSES): Rosenberg developed Rosenberg Self-Esteem Scale (RSES) for evaluating individual self-esteem. The scale consists of a total of 63 items and 12 sub-fields, which are structured from multiple choice questions. In this study, the Self-Esteem subscale composed of 10 items was used. Self-esteem subscale is a 4-point Likert-type scale ranging from strongly agree to strongly disagree with 5 positive (1, 2, 4, 6, 7) and 5 negatives (3, 5, 8, 9, 10) statements. The scores that can be obtained from the scale range from 10 to 40. High scores obtained from the scale after reversing the items show the high self-esteem of the individual (Gray-Little et al., 1997).

The reliability and validity studies in Turkey were made by Çuhadaroğlu (1989). In the Turkish validity and reliability study of RSES, 0–1-point state high self-esteem, 2-4 points state medium self-esteem, and 5-6 points state the low self-esteem of the participants. In the validity studies of the scale, the validity coefficient for self-esteem was found as .71. Test-retest reliability coefficient was found as .75 for the self-esteem subscale. In this study, the reliability coefficients of the scale were found as .90.

Experiences in Close Relationships-Revised (ECR-R): The Experiences in Close Relationships-Revised (ECR-R) was developed by Fraley, Waller, and Brennan (2000). ECR-R consists of 36-item self-report questions which examines individuals' attachment styles in two subscales: attachment related to anxiety and attachment related to avoidance. Each subscale has 18 items on a 7-point Likert-type scale graded between 1 = strongly disagree and 7 = strongly agree. Even-numbered questions measure the avoidance dimension, while odd-numbered questions measure the anxiety dimension. There are a total of 14 reverse items in the scale. Anxiety and avoidance scores were calculated for each participant by collecting and averaging the items measuring the relevant dimensions separately.

Selçuk, Günaydın, Sümer made the reliability and validity studies in Turkish, and Uysal (2005). Both avoidance and anxiety dimensions have a high level of internal consistency, and the Cronbach's alpha coefficients for these dimensions are .90 and .86, respectively. The anxiety dimension had a test-retest reliability of 0.82, while the avoidance dimension had a test-retest reliability of 0.81. In this study, the reliability coefficients for the scale's anxiety and avoidance dimensions were determined to be 0.90 and 0.91, respectively.

Family Assessment Device (FAD): The Family Assessment Device (FAD) was created by Epstein, Baldwin, and Bishop (1983) in the United States within the framework of the Family Research Program at Brown University and Butler Hospital in order to assess various dimensions of family functioning.The scale includes 7 subscales of problem-solving, communications, roles, affective responsiveness, affective involvement, behavior control, and general functions. It can be applied to all family members from the age of 12. FAD consists of 60 items that are answered through a 4-point Likert-type scale graded between 1 = strongly agree and 4 = strongly disagree. There are a total of 34 reverse items in the scale. Scores between 1 to 4 can be obtained from the subscales. A score of 1 or close to 1 indicates healthy family functioning, whereas a score of 4 or close to 4 indicates unhealthy family functioning.

Bulut conducted the Turkish adaptation study of the scale (1990). The Cronbach alpha range for subscale internal consistency coefficients was between 0.38 and 0.86. The construct validity of the scale was determined by comparing the scores of the divorced and non-divorced groups. It was discovered that the scale significantly

distinguished between these two groups. In this study, the reliability coefficient of the scale was found as .97 for the total scale, .83 for the problem-solving subscale, .86 for the communications subscale, .80 for the roles subscale, .90 for the affective responsiveness subscale, .72 for the affective involvement subscale, and .70 for the behavior control subscale.

Findings

Descriptive Findings

Mean scores and standard deviations for the variables of the study is presented in Table 2.

Table 2. Descriptive findings

Variables	N	Mean	SD
CRSS			
Positive Conflict Resolution	265	4.61	.87
Negative Conflict Resolution	265	2.34	.92
Subordination	265	3.59	1.01
Retreat	265	3.62	1.11
Self-Esteem	265	2.00	1.86
ECR-R			
Anxiety	265	3.53	1.17
Avoidance	265	2.69	1.09
FAD			
Problem-Solving	265	2.08	.76
Communications	265	2.06	.71
Roles	265	2.08	.58
Affective Responsiveness	265	2.03	.86
Affective Involvement	265	1.90	.58
Behavior Control	265	1.98	.53

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Correlations

To examine relationships among all variables, Pearson correlations were calculated. The results are presented in Table 3.

Table 3. Correlation between variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1–Positive Conflict Resolution	1	-.19**	.56	-.14*	-.21**	-.41**	-.13*	-.28**	-.24**	-.24**	-.28**	-.25**	-.29**
2–Negative Conflict Resolution		1	-.15*	-.07	.11	.12*	.26**	.03	.07	.02	.01	.09	.12*
3–Subordination			1	.29**	.10	.02	.19**	-.08	-.01	-.01	.02	.03	.02
4–Retreat				1	-.02	.20**	.03	-.06	.05	.02	.07	.02	-.03
5–Self-Esteem					1	.38**	.56**	.44**	.48**	.45**	.45**	.40**	.43**
6–Avoidance						1	.50**	.35**	.39**	.33**	.41**	.38**	.36**
7–Anxiety							1	.28**	.37**	.31**	.30**	.34**	.32**
8–Problem Solving								1	.77**	.69**	.73**	.69**	.68**
9–Communications									1	.72**	.85**	.67**	.61**
10–Roles										1	.69**	.68**	.73**
11–Affective Responsiveness											1	.72**	.64**
12–Affective Involvement												1	.71**
13–Behavior Control													1

n =265, *p<.05, **p<.01

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These correlations suggest that individuals who use positive conflict resolution styles in their romantic relationships are less likely to use negative conflict resolution and retreat styles. They are more likely to have a high sense of self-worth. They are less likely to exhibit avoidant or anxious attachment styles. Additionally, they are more likely to have healthy family functioning in their families of origin. Negative conflict resolution styles are significantly associated with anxious and avoidant attachment styles. And their families of origin are more likely to have unhealthy behavior control. Anxious attachment is more prevalent among those who use the subordination style. Avoidant attachment is more prevalent among retreat-style users. People with low self-esteem are more likely to exhibit anxious and avoidant attachment styles, as well as unhealthy family functioning. Lastly, individuals with avoidant and anxious attachment tend to have unhealthy family of origin functioning.

Regression Findings of Positive Conflict Resolution Style

As seen in Table 4, avoidance in attachment and behavior control in family of origin significantly negatively predicts positive conflict resolution style. Anxiety in attachment significantly predicts positive conflict resolution style in a positive way. 20% of the variance (R^2=.20, F=22.48, p<.05) can be explained by this model. This indicates that having avoidant attachment negatively affects positive conflict resolution style, while having healthy behavior control in the family of origin and having anxious attachment positively affects positive conflict resolution style (Low points on Family Assessment Device indicates healthy functioning).

Table 4. Regression findings of positive conflict resolution style

Positive Conflict Resolution	B	SE	β	t	p
(Constant)	5.76	.20		27.88	.00**
Avoidance	-.32	.05	-.40	-6.17	.00**
Behavior Control	-.30	.09	-.18	-3.13	.00**
Anxiety	.09	.04	.12	1.98	.04*
n=265, R=.45, R^2=.20, F=22.48, *p<.05, ** p<.01					

Regression Findings of Negative Conflict Resolution Style

As seen in Table 5, attachment anxiety significantly and positively predicts a negative conflict resolution style. 7% of the variance (R2=.07, F=20.57, p <.05) can be explained by this model. This suggests that anxious attachment positively influences negative conflict resolution style.

Table 5. Regression findings of negative conflict resolution style

Negative Conflict Resolution	B	SE	β	t	P
(Constant)	1.59	.17		9.19	.00**
Anxiety	.21	.04	.26	4.53	.00**
n=265, R=.26, R^2=.07, F=20.57, **p<.01					

Regression Findings of Subordination Conflict Resolution Style

As seen in Table 6, anxiety in attachment significantly positively predicts subordination style. Problem solving in family of origin significantly negatively predicts subordination style. 5% of the variance (R^2=.05, F=7.79, p<.05) can be explained by this model. This indicates that having anxious attachment and having healthy problem-solving in the family of origin affects the subordination style positively (Low points on Family Assessment Device indicate healthy functioning).

Table 6. Regression findings of subordination conflict resolution style

Subordination	B	SE	β	t	P
(Constant)	3.29	.22		14.49	.00**
Anxiety	.20	.05	.23	3.71	.00**
Problem Solving	-.19	.08	-.14	-2.35	.01**
n=265, R=.23, R^2=.05, F=7.79, **p<.01					

Regression Findings of Retreat Conflict Resolution Style

As seen in Table 7, avoidance in attachment and affective responsiveness in family of origin significantly positively predicts retreat style. Problem solving significantly negatively predicts retreat style. 7% of the variance (R^2=.07, F=7.40, p<.05) can be explained by this model. This indicates that having avoidant attachment and healthy problem-solving in the family of origin affects retreat style positively while having healthy affective responsiveness in the family of origin affects retreat negatively (Low points on Family Assessment Device indicate healthy functioning).

Table 7. Regression findings of retreat conflict resolution style

Retreat	B	SE	B	t	P
(Constant)	3.37	.22		15.32	.00**
Avoidance	.23	.06	.23	3.50	.00**
Problem Solving	-.40	.12	-.27	-3.14	.00**
Affective Responsiveness	.23	.11	.18	2.01	.04*

n=265, R=.28, R^2=.07, F=7.40, *p<.05, ** p<.01

Discussion

Positive conflict resolution style in romantic relationships can be defined as trying to find the root of the problems, discussing the problems constructively, trying to produce alternative solutions, and trying to reach an agreement that both parties are willing to accept (Kurdek, 1994; Özen, 2006). Avoidant attachment indicates fear of intimacy and having close relationships. People with avoidant attachment styles tend to become distant in their romantic relationships, especially during conflicts, and they tend to ignore their partners and reduce their intimacy with them (Hazan & Shaver, 1987; Feeney & Karantzas, 2017). On the other hand, anxious attachment style indicates having high levels of anxiety, obsession, tension, anger, and jealousy. People with anxious attachment styles tend to ignore their partner's needs and force them to give more attention to themselves. They feel insecure about their partner's availability, love, and responsiveness and tend to worry about rejection or abandonment (Hazan & Shaver, 1987; Feeney & Karantzas, 2017; Fraley et. al., 2015). Behavior control functioning in the family of origin refers o family monitoring and controlling behaviors, and family members create their own norms and definitions of acceptable and unacceptable behaviors. It refers to the behavioral patterns the family uses to deal with various situations such as conflicts within the family environment (Miller et. al., 2000; Epstein et. al., 1978).

People with an avoidant attachment style tend to ignore, avoid problems, and reduce their relationships with the other party rather than constructively solving problems in conflict situations in their romantic relationships. This may the negative relationship between positive conflict resolution and anxious attachment. On the other hand, people with anxious attachment style may prefer to solve problems in their romantic relationships constructively, as they have an intense fear of abandonment and neglect. This situation may predict the tendency of individuals with an anxious attachment style to use positive conflict resolution. The behavior control functioning in the family of origin determines how the family copes with conflict situations and which behaviors are acceptable. In families where this function is carried out in a healthier way, individuals may be able to cope better with conflict situations. Individuals may reflect these conflict resolution skills they acquired in their families of origin to their romantic relationships. This situation may predict individuals with healthy behavior control functioning in the family of origin to use positive conflict resolution.

When the relevant literature examined, Feeney and Karantzas (2017) stated that anxious individuals use negative conflict resolution style while avoidant individuals use retreat style. They found that anxious individuals experience more frequent and intense conflicts in their romantic relationships. Bahadır (2006) stated that anxious individuals use forcing, avoiding, accommodating, and collaborating conflict resolution styles while avoidant individuals use avoiding, accommodating, and compromising conflict resolution styles. According to Shi (2003), anxious individuals tend to use dominating and obliging conflict styles. Marshall et al. (2013) stated that anxious individuals are more likely to experience social network jealousy.

As can be seen, when the relevant literature is examined, individuals with an anxious attachment style experience intense anxiety about abandonment and neglect in their romantic relationships. This may cause them to ignore their partner's needs, become more demanding, show intense jealousy, and doubt their partner's love for them. This state of intense anxiety may predict that individuals who cannot cope constructively with conflict situations and who cannot control their behavior prefer more aggressive and negative conflict resolution styles.

Subordination style in romantic relationships can be defined as being too accepting, sacrificing own wishes and demands, compromising, fulfilling the other party's wishes, and trying not to make the problem worse (Kurdek, 1994; Özen et al., 2016). Problem solving functioning in family of origin indicates how the family reacts to the problems that threaten their integrity and functional capacity. The family can solve the problem in the most effective way (Miller et al., 2000; Epstein et al., 1978).

When the relevant literature was examined, Bahadır (2006) stated that anxious individuals tend to use force, avoiding, accommodating, and collaborating conflict resolution styles. Pancaroğlu (2007) revealed that anxious and secure individuals tend to use compromising conflict resolution style. Soylu and Kağnıcı (2015) found that there is a positive correlation between subordination style and marital adjustment. According to Koerner and Fitzpatrick (2002), how people behave in their romantic relationships depends on the communication patterns learned in their families of origin. Ülker (2011) showed that relations with the family of origin significantly predicted the frequency and prevalence of marital conflict.

As described in the previous sections, people with an anxious attachment style are very concerned about losing the other party's love and being rejected in their relationships. They may resort to obedience to relieve these anxieties and end their romantic relationships' problems before they get worse. This situation may predict the relationship between subordination conflict resolution and anxious attachment. The family's problem-solving function helps individuals deal with the difficult situations they encounter. Having this function healthy in the family of origin will enable individuals to display more moderate, positive, and submissive behaviors in their future romantic relationships. This situation may predict the relationship between problem-solving functioning and subordination conflict resolution style.

Retreat style in romantic relationships can be defined as showing passive behaviors during conflict situations. Individuals who tend to use this style prefer to ignore problems, withdraw themselves, stay silent, stay away from the conflict, and leave the problems unsolved (Kurdek, 1994; Özen et al., 2016). Affective responsiveness functioning in the family of origin indicates the capacity of family members to react appropriately to an emotional stimulus. This means family members to interact with each other, show emotional support to each other, and show appropriate emotions such as love, happiness, joy, fear, anger, and sadness (Miller et al., 2000; Epstein et al., 1978).

Children who grow up in families with healthy problem-solving functioning might prefer more moderate, submissive, and positive conflict resolution methods in their adult life. This situation may predict the relationship between retreat conflict resolution style and problem-solving functioning. The affective responsiveness functioning includes the ability of family members to react emotionally appropriately to various stimuli. Retreat style can be predicted by the unhealthy affective responsiveness functioning in the origin family, as it is a passive style that leaves problems unsolved and does not involve showing appropriate emotions in certain situations. Individuals using retreat conflict resolution style emotionally pull themselves back in conflict situations and neglect the other party's need of emotional intimacy. The low affective responsiveness functioning can explain this in their families of origin. Avoidant attachment style is defined as the fear of establishing intimacy and refraining from having close relationships. When people with this attachment style encounter a conflict situation in their romantic relationships, they tend to be passive, ignore the conflict, and engage in withdrawal behaviors that reduce their intimacy and relationships with the other party. This may predict the relationship between avoidant attachment and retreat conflict resolution style.

Conclusion and Recommendations

This study examined the predictive role of self-esteem, attachment styles, and family of origin functions in explaining conflict resolution in romantic relationships. According to the results, the predictive role of attachment styles and family of origin functions on conflict resolution in romantic relationships was found significant. However, self-esteem was not found to have a predictive role in conflict resolution in romantic relationships.

This study was conducted with both married and single individuals. In the literature, the number of studies investigating the variables of self-esteem, attachment styles, and family of origin functioning in explaining conflict resolution is limited. It is thought that this research will contribute to the literature and will be a guide for similar studies to be conducted in the future. At the same time, it is thought that this study will help academicians and researchers. While conducting case studies in the academic field, the variables in this study can be considered. Couples need help and guidance to resolve conflicts for the sake of their own mental health

and the mental health of society as a whole, because dysfunctional conflict resolution styles can be passed down from generation to generation, having a negative impact on romantic relationships and even leading to intimate partner violence.In this context, it is thought that this study will also contribute to individual awareness of the relevant issues.

Since this study includes mostly young and inexperienced individuals in terms of romantic relationships, a similar study can be done with a wider study group and age range. At the same time, studies can be conducted with other variables that can have a predictive role on conflict resolution in romantic relationships. In this study, the predictive role of attachment styles and family of origin functions on conflict resolution in romantic relationships was found significant, but the predictive role of self-esteem was not significant. In this context, the self-esteem variable can be studied by evaluating it with a different sample and a different measurement method.

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Author (s) Contribution Rate

The thesis which this article was produced from was written by the first author under the supervision of the second author. In the article preparation process, the first author prepared the introduction part while the second author prepared the method and findings parts. The discussion part was prepared by both authors. The whole manuscript was reviewed by the second author and made ready to submission.

Conflicts of Interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

Ethical Approval (only for necessary papers)

Ethical permission (13.04.2021/16) was obtained from Yeditepe University Social Sciences Ethics Committee for this research.

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Developing Writing Skills, Writing Attitudes and Motivation through Educational Games: Action Research

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Developing Writing Skills, Writing Attitudes and Motivation through Educational Games: Action Research

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Abstract

This study aims to improve the writing skills, motivation towards writing, and writing attitudes of elementary school students through educational games by eliminating the problems they encounter in the writing process. The study was designed within the scope of cooperative action research, and criterion sampling was used for the sample selection. The data collection tools included Writing Attitude Scale, Writing Motivation Scale, Analytical Rubric for Assessing writing, interview forms, educational games, and action plans. The qualitative and quantitative data were analyzed using a series of data analysis techniques. The quantitative results showed that the participants' post-test mean scores in such dimensions of using educational games as attitude, motivation, and writing skill development in the writing teaching process were higher than their pre-test mean scores. The qualitative results revealed that the educational games could be used as an effective technique in teaching writing to develop participants' positive attitudes towards writing, increasing their motivation, improving their writing skills, and eliminating writing problems. Based on the results, it could be stated that different techniques, such as educational games, should take place more in the process by considering the affective factors in teaching writing.

Keywords: Writing skills, Writing motivation, Attitude towards writing, Action research, Educational game.

Introduction

Writing skill, which includes cognitive, affective, physiological, and social processes, is a complex and difficult skill to acquire among the four language skills. Writing in the form of a mere narration skill is insufficient to express the depth of writing. In contrast, writing is a versatile tool to achieve the goals through ways of learning and teaching. Written language is used in establishing interpersonal communication by integrating vocabulary with content knowledge, transferring feelings and thoughts in written forms, organizing thoughts, and being a mediator of learning.

Considering that writing, an activity requiring the use of high-level skills and supporting development, covers many literacies beyond alphabet writing, the importance of teaching writing at all levels cannot e denied. The process of teaching writing can include the dimensions of knowledge about writing and writing issues, producing and processing texts, motivation, and directing thoughts and actions through appropriate strategies to achieve writing goals (Graham, 1997). In other words, teaching writing involves studying on the development of knowledge and skills about exhibiting many behaviors, from applying spelling, punctuation and grammar rules, emphasizing important expressions with the use of appropriate words to presenting the content as a meaningful whole. In addition, the further purpose is to develop writing strategies such as planning and revising through writing instruction (Graham, 2006; Nightingale, 1988).

It is emphasized that writing instruction increases students' ability to acquire, understand, construct and reflect new information (Defazio, et al., 2010; Graham & Perrin, 2007; Klein, 2000; Montelongo & Herter, 2010), supports developing language skills (Graham & Hebert, 2011; Huy, 2015) and leads to academic success (Handayani & Siregar, 2013; Waring, 2007). Moreover, students have the opportunity to verbally convey their feelings and thoughts to their peers and teachers through written products (Moses & Mohamad, 2019). In another saying, writing activities help students develop their writing and verbal communication skills.

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Whether teaching first or second language, it is possible to encounter some problems in teaching instruction. Although the problems encountered in the writing process are specific to the learner, the following problems arising from the teaching method used in the language teaching process (Al-Khasawneh, 2010; Batur & Özdil, 2018) are seen as the most common problems in writing instruction literature: lack of learner/teacher motivation and/or interest (Zimmerman, 1989), reluctance to share written products (Huy, 2015), failure to receive appropriate feedback (Lee, 2003; Sigurðardóttir, 2010), making mistakes in writing due to poor vocabulary knowledge and grammatical inadequacy (Ayık, 2019; Moses & Mohamad, 2019; Rabab'ah, 2003; Sheeba, 2016; Zorbaz, 2010) and other similar problems. Troia (2003) suggests that the problems students experience in effective writing can be attributed to the difficulties in executing and arranging the writing teaching process in terms of the dimensions of creating, planning, and reviewing this process. Similarly, Mustaque (2014) states that although students have knowledge about vocabulary and grammar rules, they encounter some problems in structuring that knowledge. In this respect, when the literature is generally examined, the importance of cognitive skills in the writing teaching process draws attention. Besides these cognitive factors, affective components are also important in terms of becoming qualified in writing skills.

Considering the effect of factors like anxiety, interest, attitude, and motivation on the writing process and success in writing in terms of the affective dimension (Bruning & Horn, 2000; Buyse, 2006; Chea & Pel, 2013; Graham, 2006; Hamp-Lyons & Heasley,1987; Hidi & Boscolo, 2006; Lam & Law, 2007; Lo & Hyland, 2007; McClenny, 2010; McGettigan, 2008; McLeod, 1987; Pajares, 2003), affective structures should be carefully constructed in the teaching process. In fact, with the teaching of writing, students at all levels of education are expected to be capable of not only expressing themselves correctly in written forms, but also making sense of the importance of writing skills. Carroll (1990) emphasizes that it is difficult for students to realize the importance of writing in terms of learning when they only interpret the writing process as the correct learning of spelling and grammar and reflecting it on their writing. Considering this possibility, it could be stated students should get actively and willingly involved in the activities to make the learning experience meaningful and valuable in writing activities.

The fact that most of the writing activities in the teaching process depend on classroom practices makes it necessary to form the instructional design carefully. In this respect, encouraging students to participate in writing activities and improving their writing skills require a systematic pragmatic approach. Accordingly, the teacher should first focus on the writing skills students need to develop and then decide on selecting appropriate methods, techniques, and tools to be used in the teaching process. Once the target skill areas and implementation tools have been identified, the teacher can begin focusing on what topic can be used to engage students and can go on to think about how to involve students in the process, considering the types of activities that interest students. In other words, the teacher should provide a context where effective learning can be achieved in the target area by choosing an appropriate topic in line with students' interests and needs. However, it could be stated that a teacher who can pragmatically integrate these goals can expect an effective writing teaching process to occur (Adas & Bakir, 2013).

In order for students to produce good-quality written products in the future, writing activities should be carried out starting from the early stages of education (Ling, 2016). The time devoted to teaching writing is very important in this respect. However, it is seen that teachers cannot allocate enough time to writing instruction for various reasons (inability to keep up with the curriculum, insufficient course hours, student reluctance, etc.) (Huy, 2015; National Commission on Writing, 2003). In this respect, the possible consequences of failure to allocate enough time to teaching writing draws the attention in the literature. Stein, Dixon, and Isaacson (1994) argue that many mistakes in writing may result from too little time devoted to teaching writing or from poorly designed writing instruction to meet the learning needs of many students. According to Leki, Cumming, and Silva (2008), lack of studies on the development of writing skills and teachers' lack of knowledge on this subject cause students to have difficulties in writing skills. In other words, inadequate involvement of writing in the teaching process, the inadequacies of teachers and failure to design the teaching process in line with the purposes cause the writing skill not to develop.

In addition to the importance of the time devoted to teaching writing, teachers also need to use different approaches, methods and techniques to draw students' attention to writing. In literature, it is seen that different methods and techniques are used to improve students' writing skills in terms of various variables. Whether in the mother tongue or in the foreign language teaching process, positive results are encountered when the methods and techniques used in language teaching focus on language skills, which need to be developed. In the process of teaching first language as well as foreign language, positive results are encountered when the methods and techniques to be used in language teaching are employed in the focus of language skills that need to be developed. For example, in their research, Adas and Bakir (2013) revealed that the processes designed with the

blended learning method to improve students' writing skills were effective in developing students' writing skills. Göçen (2019) concluded that creative writing practices had positive influence on elementary school students' writing success, motivation and attitudes. Handayani and Siregar (2013), who investigated the effect of a process-oriented writing approach on writing skills, found that this approach significantly increased students' success in writing expository texts.

Although there are many different techniques to be used in writing instruction, it could be stated that one of these techniques is the educational game technique. It was demonstrated by meta-evaluations (Genç-Ersoy, 2021) that educational games are a very effective technique in student acquisition, primarily in supporting the development of language skills. Real communication environments created with educational games are important language learning environments that can be used in this context (Larsen-Freeman, 2000; Lee, 1979), and it is possible to develop language skills in these environments (Christakis, Zimmerman & Garrison, 2007; Lee, 1995; Wrigth, Betteridge & Buckby, 2006). Whether it is a digital environment or not, it is stated that educational games increase student motivation in the development of language skills, support communication, and cooperation among students, increase students' willingness to participate, support learning tasks, and facilitate learning (Aydın, 2014; Christakis, Zimmerman & Garrison, 2007; Hung, Sun &Yu, 2015; Jubran, 2019; Valipour & Aidinlou, 2014; Wright, Betteridge & Buckby, 2006).

Undoubtedly, educational games can be used in the development of all language skills. The opinions put forward about the use of educational games in the process of writing instruction, which was particularly the focus of this study as well, defend that it saves learning writing from boringness (Allen et al., 2014; Jackson & McNamara, 2013), improve writing skills (Windiyani, Boeriswati & Sumantri, 2019), and supports higher-order thinking skills in creating written products (Song, 2008).

The fact that the language used in the writing process has aspects different from the language used in speaking may cause students to approach writing more cautiously. The use of educational games in writing instruction emerges as an effective technique to prevent this situation because games are not only fun for learners; they can also provide many reasons to use their writing skills to play the game. In this respect, it would not be wrong to say that it is an effective way to experience the language in terms of providing emotional support in the development of learners' language skills in teaching writing with educational games. In fact, some studies revealed that educational games provide learners with affective support in such dimensions as attitude and motivation in writing (Allen, et.al., 2014; Ayık, 2019; Chang, Liao & Chan, 2021). In addition, educational games allow students to get the feedback they need and correct writing mistakes as they use their writing skills (Hadfield & Hadfield, 1990). The reasons show that educational games can make positive contributions to learners in the process of teaching writing.

Considering the students' need for intrinsic motivation in the process of teaching writing and existing support in the teaching environment (Lam & Law, 2007), educational games could be an effective technique in eliminating the problems experienced by students and improving their writing skills. In this respect, the writing skill, with its important place in people's lives, should be understood with all its dimensions, and the focus should be on developing it as a whole with other language skills. Teachers competent in using the educational game technique should undertake an important role in allowing students to make sense of writing skills, solve writing problems, and develop positive attitudes and high motivation towards writing. For the aforementioned reasons, the fact that the expert elementary school teacher, one of the researchers of this study with four years of experience teaching elementary school students, collaborated with field experts and applied scientific research-based methods to solve the writing-related problems encountered by these students was deemed beneficial for both the students' development and the teacher's professional development. In addition, aiming to solve class-specific problems through meaningful and enriched instructional designs in the classroom will gain an important place in the literature.

In this respect, this study aimed to improve elementary school 4th-grade students' writing skills, attitudes toward writing, and motivation in writing through educational games by eliminating the problems they faced in the writing process. The study also seeks to determine the average scores of students' skills, attitudes, and motivation related to writing and to examine the difference that educational game applications make on these variables. In line with these purposes, the research questions can be listed as follows:

- What are the problems experienced by elementary school 4th-grade students in their writing processes?
- What are elementary school 4th-grade students' attitudes towards writing?
- What is the motivation of 4th-grade elementary school students in writing?

- Do educational game applications significantly affect the average scores of elementary school students regarding the development of writing skills, their attitudes towards writing and their motivation to write?
- What are the students' opinions about the educational game applications carried out?

Method

This study aimed to determine the problems elementary school 4th grade students face in the process of performing writing and to improve their writing skills, attitudes, and motivations towards writing through educational games. Accordingly, the study was designed within the scope of cooperative action research. Cooperative action research is a type of practice-oriented action research in which the researcher and practitioner collaborate to identify problem areas in practice, potential causes of these problems, and potential interventions (Holter & Schwartz-Barcott, 1993; cited in Yıldırım & Şimşek, 2018).

The Study Group

Considering the nature of action research, it is a type of research used to understand or solve a teaching problem by collecting and analyzing data about a topic or problem that teachers have determined as the basis of the teaching process (Calhoun, 1994), the problem to be studied on must be specific to that class. In this respect, while determining the study group, the criterion sampling technique was used to examine the problem situations in depth. Accordingly, the students who had problems in the writing process were included in the sample, considering the teacher's observation before the intervention, the opinions obtained from the interviews before the intervention, and the scores in writing before the intervention. In line with this, 23 elementary school 4th grade students who had some problems in the writing process were included in the research sample, taking into account the teacher's observations before the application, the opinions obtained from the interviews held before the application, and the scores of the writing studies carried out before the application. The participants in the study group were elementary school 4th grade in a public school in 2020-2021 in Marmaris, a district of the province of Muğla. The study group consisted of 17 male and six female students. The students in the study group had been in the same class with their teacher for at least three and at most four years. The writing scores of the students in the study group before the application were ten points at the highest and four points at the lowest. When their writing scores were evaluated in general, it was seen that they achieved a low achievement score.

Data Collection Tools

The data collection tools in the study consisted of the Writing Attitude Scale (WAS), Writing Motivation Scale (WMS), Analytical Rubric for Assessing Writing (ARAW), and educational games and interview forms developed by the researchers. Other data sources in the study were written products of the study group, unstructured observation, student diaries, and researcher diaries.

Writing Attitude Scale (WAS): The scale developed by Susar Kırmızı (2009) was a valid and reliable tool in determining elementary school 4th and 5th grade students' attitudes towards writing. The scale included 34 items developed as a 5-point Likert-type and rated as "Totally Appropriate, Fairly Appropriate, Partially Appropriate, Slightly Appropriate, Totally inappropriate". The factor eigenvalues of the items varied between 0.50 and 0.86. The Cronbach Alpha reliability coefficient of the scale was .90. The weighted raw score each student could get from the scale was a minimum of 34 and a maximum of 170.

Writing Motivation Scale (WMS): The scale developed by Öztürk (2013) was a valid and reliable tool for determining the motivation of elementary school 4th-grade students in writing. The scale had a five-factor structure, and 22 items developed as a 5-point Likert-type and rated as "Very suitable for me, Suitable for me, Undecided, Not suitable for me, Not very suitable for me". These factors were "positive attitude towards writing", "having a purpose", "failure to convey ideas into writing", "shared writing", and "writing effort". The Cronbach Alpha reliability coefficient of the scale was .81.

Analytical Rubric for Assessing Writing (ARAW): It was a measurement tool developed by Bilican Demir and Yıldırım (2019) to evaluate the writing skills of elementary school students, and the validity and reliability studies of the scale were carried out. The tool allowed evaluation of students' writing with a four-point scoring rubric according to the criteria of content, discourse management, intelligibility, language use appropriate to the context, spelling, and grammar. The scores to be obtained according to the level of meeting the criteria in question were "Beginner level = 1 point", "Improvement needed= 2 points", "Acceptable level = 3 points," and

"Fully successful = 4 points". The lowest score to be obtained for each writing was 6, while the highest score was 24.

Interview Forms: Three interview forms were developed by the researchers and employed before, during and after the intervention, and constituted the qualitative data collection tools in the study. Semi-structured interview forms were applied through face-to-face interviews with the participants in the study group. The first form was an interview form created to determine the problems related to writing skills before the intervention. With this form, the problems experienced by the study group in writing were determined via the participants' responses to the questions, and answers were sought to form action plans for problem solving and to let the participants overcome these problems. A total of five questions and their probes were included in the first interview form. In the focus of the first form, there were questions about how the participants made sense of the writing process and what they needed in relation to the things that challenged them in the writing process.

The second interview form was applied to the study group during the intervention. The form's content was prepared to determine the functionality of the action plans, the problems experienced and the students' views about writing. In line with this, seven questions were included in the form. In the focus of this form, there were questions about determining what had changed in the participants' writing as a result of the application.

The third interview form, employed at the end of the intervention, consisted of semi-structured questions allowing the study group to evaluate the intervention and the development of their writing as a whole. Before the interview forms were applied, they were examined and evaluated by field experts regarding form, content and meaning. In line with the feedback received from the field experts, some changes were made in the formal and semantic dimensions of the forms, and the forms were finalized.

Educational Games: During the interventions, writing-focused educational games aiming to improve the study group's writing skills, attitudes and motivations were used. Accordingly, for use in the intervention, eight educational games named ice cubes, garden for writing, word track, I'm dubbing, wheel of fortune game, I'm creating my story, dice and puss in the corner were developed by the researchers. Two specialists in the field of educational games in language instruction were asked for their thoughts on the games and their approval was gained. Although different sub-dimensions for the development of writing skills were studied with the educational games developed, the affective dimension was supported in all games by considering the entertainment factor and education. The goals of these educational games are mentioned briefly below.

Ice cubes is an educational game that aims to support the grammar dimension to support the study group to make sentences according to their level. The use of synonyms, antonyms and words with real and metaphorical meanings was also supported with the game.

The garden for writing game is an educational game that aims to develop and improve the comprehensibility of the writing process. With this game, the study group was supported to design writing processes that would support the use of words without repetition by working on the ambiguities in their written products.

Word track is an educational game that aims to teach vocabulary to improve the vocabulary knowledge of the participants in the study group. With this game, the purpose was to help develop content, one of the dimensions of writing skills.

With the game of *I'm dubbing*, the purpose was to develop the discourse management of the participants in the study group. The game aimed to use connectors and linguistic expressions to enrich the text within the context determined.

With the *Wheel of Fortune game,* the purpose was to help the study group improve their use of language appropriate to the context in the writing process. Appropriate writing products were developed for the contexts on the wheel of fortune in the game.
With the *dice game,* the purpose was to improve the writing skills of the study group in the dimension of spelling rules. In line with this, the focus was on emphasizing spelling and punctuation rules and creating products according to the rules.

The games of *I'm creating my story, dice,* and *puss in the corner,* the purpose was to develop and put into practice all aspects of the writing process (content, discourse, intelligibility, context, spelling rules, grammar) as a whole with the corner games. These two games, which are included in the action process and are the last games, played an important role in the presentation of the development status of the writing problems of the

working group. These two games, which were included in the action process as the last games, played an important role in presenting the development and writing problems of the study group.

Written products: Written products were used to determine the study group and to identify the writing problems. In line with this, four writing studies were carried out with the study group before the application. Within this scope, the study group carried out writing activities covering the text types and topics envisaged by the Turkish curriculum. In the implementation process, with eight educational games embedded in three action plans, a total of eight writing exercises were done at the end of the teaching process. The writing activities were carried out with the focus of controlled, guided, creative and free writing techniques.

Diaries: Diaries included students' diaries and researcher's diary. The practitioner researcher kept the researcher's diary throughout the application in order to prevent researcher bias and ensure reliability. On the other hand, students' diaries were written by the study group after eight educational games applied similarly to the written products. In terms of the content of the diaries, the study group was asked to express what they felt during the application, the difficulties they experienced and their own developments. The data obtained from the diaries in question were used to support the data obtained from the writing scores, scales, and interviews. In this respect, the expressions especially in the affective dimension gained importance.

Unstructured observation: The practitioner researcher collected the unstructured observation form throughout the application processes. The participant and action cycle dimensions were taken into account in the observation process. In accordance with this, the difficulties encountered in writing during the application process, the responses received from the participants, and the experiences linked to the problem-solving process were all recorded.

Action process

The process followed for implementing the action plans employed in the study is given in Table 1.

Table 1. Action process

Period	Time	Action Taken	Data Sources
Before the application	Week 1	Free writing (1st writing activity)	Products of writing Observation form Researcher's diary
	Week 2	Writing on Atatürk (2nd writing activity)	Products of writing Observation form Researcher's diary
	Week 3	Writing on Republic (3rd writing activity)	Products of writing Observation form Researcher's diary
	Week 4	Narrative writing (4th writing activity)	Products of writing Observation form Researcher's diary
	Weeks 1 and 6	Holding the first interviews to determine the study group	First interview form Observation form Researcher's diary
During the application	Week 7	Application of the attitude and motivation scales as pre-tests	WAS WMS Student's diary Researcher's diary Observation form
	Weeks 7, 9 and 10	Application of the action plan (Implementation of the educational games, carrying out the writing activities)	Products of writing Researcher's diary Observation form
	Week 10	Holding the second interview with the study group	Second interview form Observation form Researcher's diary
	Weeks 11, 12 and 13	Carrying on the application of the action plan (Implementation of the educational games, carrying out the writing activities)	Products of writing Student's diary Researcher's diary Observation form
	Week 14	Application of the attitude and motivation scales as post-tests	WAS WMS Researcher's diary

			Observation form
After the application	Week 15 and 16	Holding the third interviews with the study group	Third interview form Observation form Researcher's diary

A 36-hour application was carried out in the action process to develop writing skills, attitude towards writing and motivation with the help of educational games. Three different action plans were employed in a total of six weeks of the 16-week application. There were plans designed with educational games as the focal point of the action plans. These plans were intended to improve the dimensions of the study group's main writing problems. These problems included issues with the content (being related to the given topic or event such as selected words, sentences, idioms, examples, etc.), discourse management (including linguistic expressions, expansions, and connectors that will enrich the writing in the context determined), and intelligibility (ambiguity in conveying the text content) (sentences made according to the level obeying grammatical rules).

Validity and Reliability

The stages proposed by Johnson (2002) were taken into account in ensuring accuracy and credibility as well as validity and reliability in action research. Accordingly, long-term observation, keeping researcher's diary to prevent researcher bias, long-term interaction, data triangulation, expert review, detailed description, and reporting were carried out in the study. In addition, a validity committee of three field experts was established to examine, discuss, and evaluate the applications and to make additional arrangements during the research process. A total of four meetings were held with the validity committee, once before the intervention, once after, and twice during the intervention.

Data Collection

The research process was conducted in a total of 16 weeks, including determining the problem situation (6 weeks), application of the pre-test and post-test (2 weeks), application of the action plans (6 weeks), and determining the opinions after the intervention (2 weeks). In the study, to identify the problems experienced by the participants in the writing processes, free and subject-oriented or genre-contextual writing activities were carried out once in a week or in four weeks by the study group regarding the themes and subjects, which were the natural elements of the curriculum. During the writing activities, the practitioner researcher kept observation notes and a researcher's diary. The writing activities were evaluated with ARAW, which determined the study group and the sub-dimensions of writing skills that needed to be developed. In the following process, the first interviews were held to make sense of the problems experienced by the students in the writing processes, their attitudes towards writing and their motivation in writing and to enable them to express themselves verbally as well. With the interviews, a road map was drawn for which action would be useful in solving the problem. In this way, the problem situation and the study group were determined before the intervention. An action plan was created for the solution of the problem situations revealed in the light of the writing products of the study group, the themes and concepts emerging as a result of the first interviews, and the attitude and motivation scores, and the researchers developed eight educational games that were thought to help solve the problem.

WAS and WMS pre-tests were applied to the study group before the action plan was put into practice. At this stage, the practitioner researcher asked the participants to share their experiences, feelings, and so on via the diaries distributed to them in which they could express what was important during the intervention. The participant diaries were used to provide qualitative data to help the researchers reveal how the participants made sense of the intervention process. In the following process, the action plan was implemented in a way that an educational game was played every week for eight weeks. Although the playing times of the educational games varied between 30 and 40 minutes, the educational game's preparation, playing and evaluation were carried out in three lesson hours in a week. In addition, at least one writing study was conducted within the scope of each educational game. Accordingly, each writing product was evaluated with ARAW, and the scores were recorded. After the three-week action plan intervention, second interviews were held to examine the situation, to determine the problems experienced in the action process, to identify the aspects needing improvement and to get the evaluations of the study group regarding the process. After the second interviews, the action plan application continued, and the second three-week intervention cycle was started. Similar to the first three weeks, following the action plan, writing activities were carried out within the scope of the educational games, and the development of the writing skills of the study group was evaluated. Following the completion of the process that took place over the course of six weeks, the action plan was finalized when the issue was resolved. This was accomplished by taking into account the rise in the writing scores of the study group as well as the data collected through the interviews.Just after the action plan was finalized, the post-tests were applied, and the

changes in the attitudes and motivations of the study group were evaluated. After the intervention process, third interviews were held with the study group to allow them to evaluate themselves, the process and their writing.

Data Analysis

Before, during, and after the intervention, a variety of data analysis approaches were employed to assess the qualitative and quantitative data collected in the study.After the intervention, data were examined and interpreted as a whole. For the analysis of the quantitative data, the data obtained through WAS and WMS were transferred to SPSS 24 package program, and paired samples t-tests were conducted for attitude, motivation, and success. The writing products obtained from the study group were analyzed with ARAW, and the numerical data obtained were presented as total scores and in tables to show the progress.

For the analysis of the qualitative data, interviews, researcher's diary, participants' diaries, and observation forms were analyzed separately by the researchers using content analysis. NVIVO 12 program and an online site for concept formation were used to determine and model the relationships between the themes. In this respect, the process was followed by coding the data, finding the themes, organizing the codes and themes, and defining and interpreting the findings.

Results

Quantitative Results

This section presents the analysis results of the findings obtained through Writing Attitude Scale (WAS), Writing Motivation Scale (WMS) and Analytical Rubric for Assessing writing used in the study. Table 2. prepared accordingly summarizes the descriptive statistics of the study.

Table 2. Descriptive statistics regarding the quantitative data

	X̄	Max	Min	Sd	Variance	Skewness	Kurtosis
WAS_1	111.608	130.000	68.000	.481	235.249	-1.403	1.863
WAS_2	138.652	151.000	114.000	.481	69.964	-1.139	2.148
WMS_1	77.217	106.000	47.000	.481	182.451	-.118	.514
WMS_2	95.130	107.000	84.000	.481	43.028	.024	-.951
WS_1	47.60	80.000	25.000	.481	227.976	.563	-.066
WS_2	72.34	96.000	50.000	.481	277.874	.005	-1.644

WAS_1: WAS pretest; WAS_2: WAS posttest; WMS_1: WMS pretest; WMS_2: WMS posttest; WS_1: Writing Pre-intervention Score; WS_2: Writing Post- intervention Score

As summarized in Table 2. the post-test mean scores in all three measurement tools were higher than the pre-test means scores. Byrne (2010) suggested a value range of -2 to +2 for skewness and -7 to +7 for kurtosis. When evaluated together with these findings, the outlier analyses and histogram graphs revealed that the data had a normal distribution. To test whether the differences between the mean scores obtained from the data collection tools were significant, paired samples t-tests were performed by considering the pretest-posttest mean scores of each variable. Table 3. summarizes the t-test results for attitude towards writing:

Table 3. Paired samples t-test results regarding attitude toward writing

Measure	N	X̄	Sd	df	p	t
WAS_1	23	111.60	15.33	22	<.001	-7.178
WAS_2	23	138.65	8.36			

WAS_1: WAS pretest; WAS_2: WAS posttest

As can be seen in Table 3. there was a significant difference in favor of the post-test between the post-test and pre-test scores of the Writing Attitude Scale ($t_{(22)}$=-7.178, p<.001). The findings showed the participants' attitudes increased as a result of the intervention. Table 4. presents the results of the paired samples t-test regarding motivation in writing, and the results of the paired samples t-test regarding the writing success of the participants are shown in Table 5.

Table 4. Paired samples t-test results regarding motivation in writing

Measure	N	X	Sd	df	p	t
WMS_1	23	77.21	2.81	22	<.001	-7.268
WMS_2	23	95.13	1.36			

WMS_1: WMS pretest; WMS_2: WMS posttest

According to Table 4. there was a significant difference between the post-test and pre-test scores of the Writing Motivation Scale in favor of the post-test ($t_{(22)}$=-7.268, p=<.001). The findings revealed that the participants' motivation increased in line with the intervention, similar to the findings regarding the attitude towards writing.

Table 5. Paired samples t-test results regarding success in writing

Measure	N	X	Sd	df	p	t
WS_1	23	47.60	15.09	22	<.001	-7.070
WS_2	23	72.34	16.66			

WS_1: The writing success score before the intervention; WS_2: The writing success score after the intervention

As can be seen in Table 5, there was a significant difference between the participants' pre-intervention and post-intervention scores, in favor of the post-intervention scores ($\bar{X}$=72.34) ($t_{(22)}$=-7.070, p<.001). The findings showed that the participants' writing success increased in line with the intervention, similar to the findings related to motivation and attitude towards writing.

Qualitative Results

The study's qualitative findings are presented in two sub-titles: the results obtained from the interviews and those obtained from the diaries and observations. Accordingly, the findings obtained from the interviews held before, during and after the intervention are given, and then the findings obtained via the participant diaries, researcher diary, and observation notes are presented.

Results Obtained via the Interviews before the Intervention

The findings obtained before the intervention and while determining the study group showed that the participants' views were gathered under three main themes. Accordingly, the sub-themes and concepts under the main themes of "Challenges in the Writing Process" and "Needs related to the development of the Writing Process" are presented in Figure 1. and Figure 2. The sub-themes and concepts that emerged regarding the challenges in the writing process are shown in Figure 1.

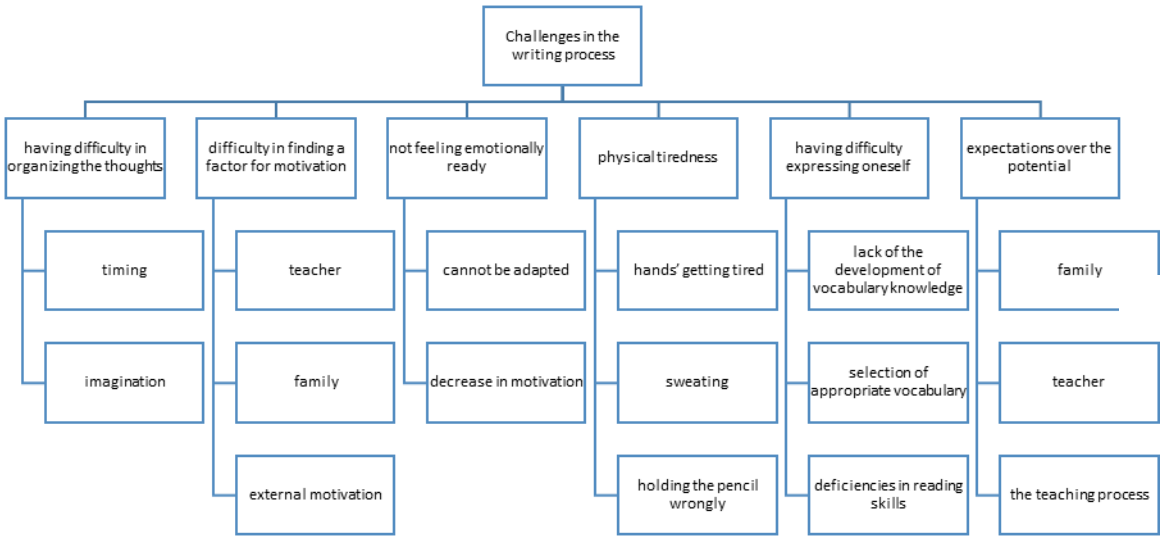

Figure 1. Challenges in the writing process

The research results showed that the participants had difficulties in organizing their thoughts during the writing process, choosing appropriate words because they could not express themselves due to the lack of development of their vocabulary, and finding an external motivational element, especially the teacher and their families. In addition, the participants did not feel emotionally ready; they felt unmotivated and unable to adapt to the writing process as a teaching process, and their families and teachers had expectations of their own potential.

Another difficulty the participants encountered in the writing process was the symptoms of physical fatigue. One of the remarkable results was that long and difficult writing tasks given above the potential and previous erroneous learning, such as inappropriately holding the pencil, caused fatigue of the hands and stress factors such as sweating, which appears as a physical expression.

Figure 2. presents what the participants needed to overcome the difficulties they encountered in the writing process and to improve their writing skills.

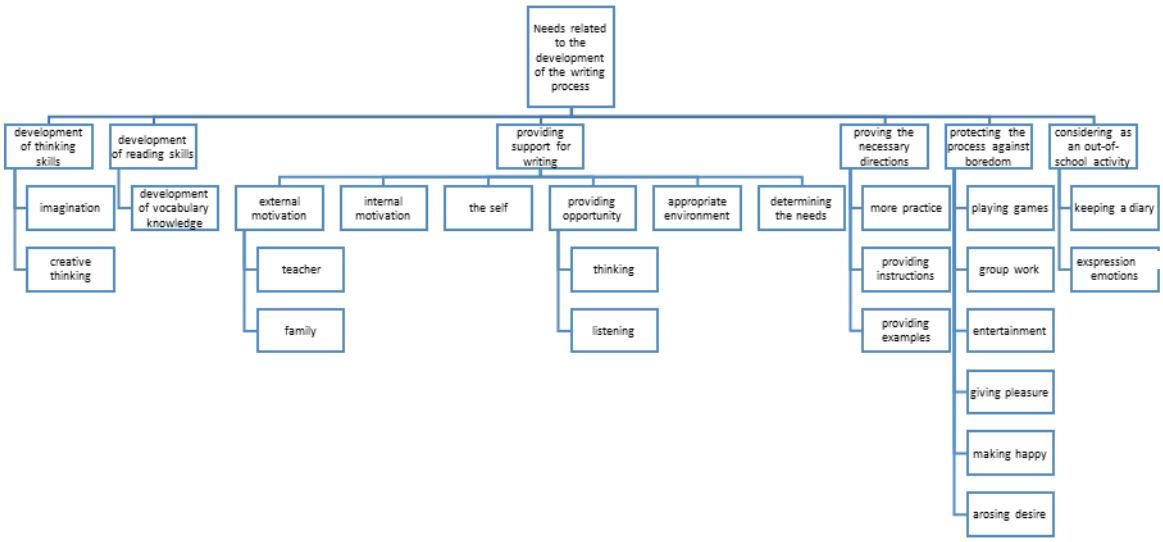

Figure 2. Needs related to the development of the writing process

The finding related to the need for learning with games, which was stated by almost all the participants in meeting the participants' needs in developing their writing skills, also shaped the implementation process of this study. The fact that the writing process should be fun by getting rid of the boredom, arouse desire, make them happy, give pleasure and provide the opportunity to work in groups constituted the basis of the requirements in the development of the writing process. In addition, the research findings showed that guidance for the development of thinking and reading skills and presentation of instructions and examples in the writing process should be provided for the participants to overcome the difficulties they encountered and to improve the writing process should be provided.

In providing writing support, it is noteworthy that teachers and families should especially support the participants in terms of providing a suitable environment for them, determining their needs, giving them opportunities to think and rest, and providing motivational sources. The results obtained before the intervention showed that some compelling factors were effective for the participants to make sense of the writing process and that these factors caused them to develop negative attitudes and low motivation during the writing process. In addition, it was revealed that the teachers and families had a role in the emergence of these factors and that certain things were needed to overcome the difficulties encountered and to develop writing skills.

Results Obtained via the Interviews Held During the Intervention

The results obtained via the interviews held during the intervention showed that the participants' views were gathered under three main themes. Accordingly, the sub-themes and concepts under the main themes of "Making sense of the Writing Process," "Adventure of Writing" and "Development of Writing Skills" are presented in Figure 3., Figure 4. and Figure 5. In figures, lined arrows depict the relationship between the concepts and the sub-themes, while dashed arrows indicate the interrelationships among the concepts.

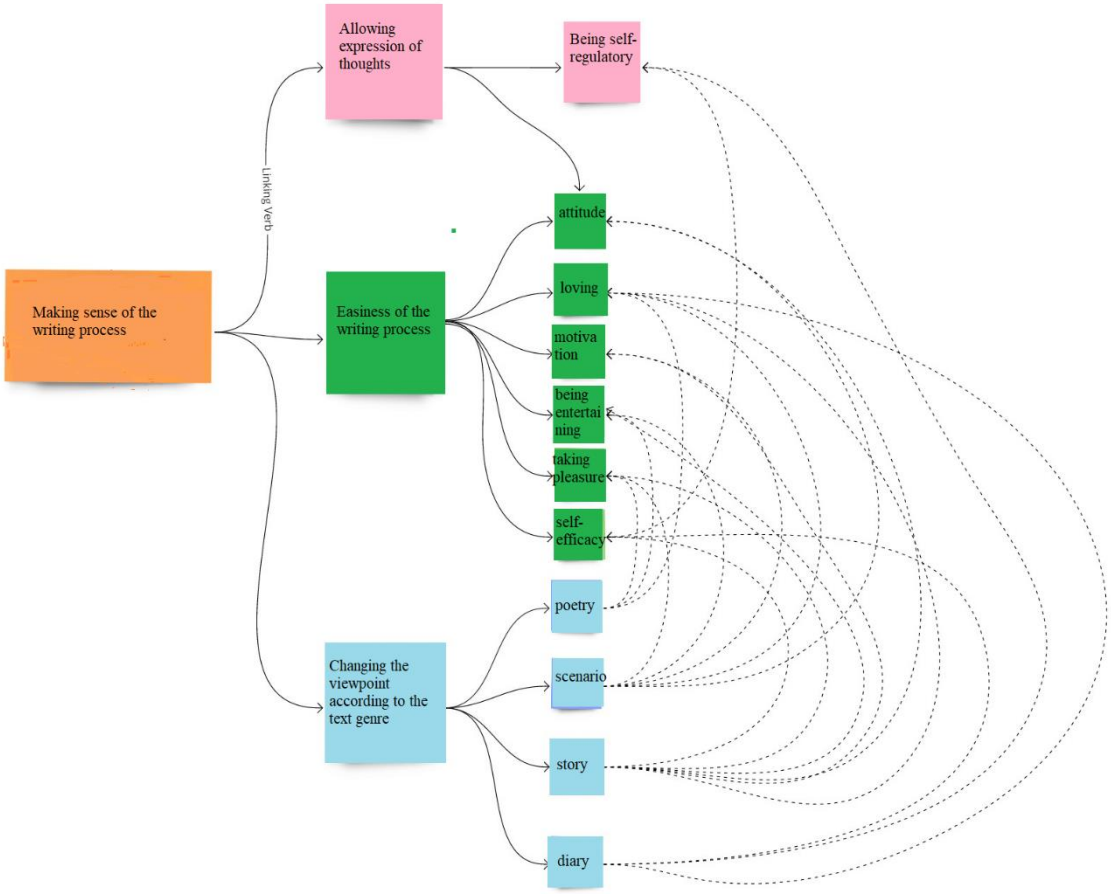

Figure 3. Making sense of the writing process with the applications

With the applications in Figure 3, some developments occurred in the participants' making sense of the writing process compared to the pre-intervention process. As stated particularly in the previous sections, it was noteworthy that the factors effective in expressing thoughts disappeared with the intervention process and that being self-regulatory was emphasized to be effective on ensuring the expression of thoughts. In this respect, the writing activities carried out through educational games increased the participants' awareness in making sense of the writing process, allowed them to find the writing process easier than before the intervention, and helped them develop positive attitudes. In addition, it was noteworthy that lack of self-confidence was replaced by self-confidence; that the feeling of not liking writing was replaced by the feeling of liking it; that dislike of writing and the feeling of finding it boring were replaced by fun and entertainment; and that motivation for the writing process improved. Additionally, similar to the results obtained before the intervention, the sub-theme of the change in viewpoint in accordance with the genre of writing was expressed with similar concepts. The point that distinguished the result as mentioned above from the results obtained before the intervention was that the writing activities carried out with the highlighted text genres mentioned was found entertaining by the participants. They had the motivation and positive attitudes towards writing in the mentioned writing genres.

Figure 4. presents the sub-themes regarding the applications carried out to improve writing skills through educational games and their reflections on the conceptual relations under the sub-themes. In figures, lined arrows depict the relationship between the concepts and the sub-themes, while dashed arrows indicate the interrelationships among the concepts.

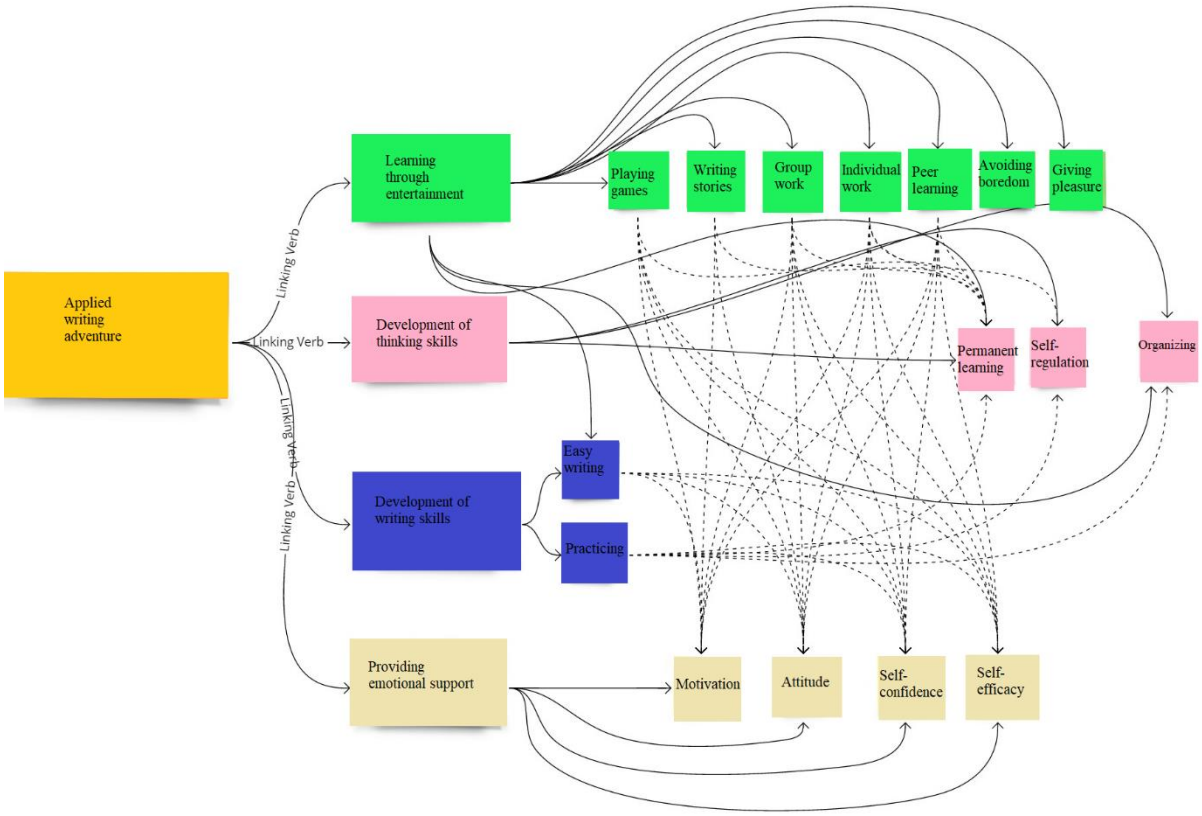

Figure 4. Applied writing adventure

According to Figure 4. it was noteworthy that the sub-themes and the concepts related to the sub-themes affected each other and had a direct intense relationship. The results showed that the participants evaluated writing practices supported with educational games in the dimensions of learning with fun, improving thinking and writing skills, and providing emotional support.

Other results included that applications such as game playing and story writing carried out in groups or individually saved the learning process from being boring, made the process fun and enjoyable, and supported permanent learning, peer learning and self-regulation skills. In addition to learning by having fun, other remarkable results obtained in the study included the fact that the participants could write more easily in the context of the development of writing skills and that the participants could receive emotional support such as motivation, attitude, self-efficacy and self-confidence with the learning process and development.

Figure 5. presents the effect of writing activities supported with educational games on the development of writing skills. In figures, lined arrows depict the relationship between the concepts and the sub-themes, while dashed arrows indicate the interrelationships among the concepts.

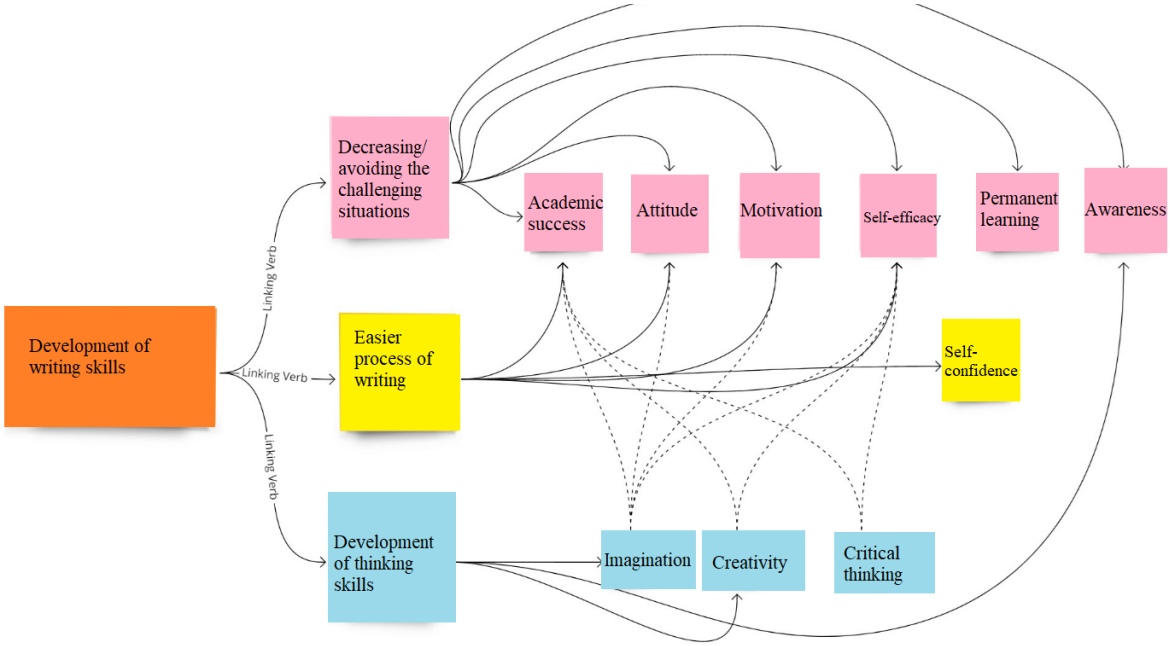

Figure 5. Development of writing skills

The results showed that the applications carried out through educational games contributed to developing the participants' writing skills. The participants emphasized that the thinking skills they needed were supported in the development of writing skills before the intervention and that the difficulties in the writing process decreased or disappeared.

Other notable results include that participants perceive the writing process more easily due to the disappearance of the difficulties encountered, that their academic success and self-confidence increase accordingly, that sustained learning is ensured, and that they develop their motivation and a positive attitude toward writing.Moreover, the participants' awareness of the improvement of their writing skills with the applications increased as well.

The Results Obtained via the Interviews Held After the intervention

The results obtained via the interviews after the intervention showed that the sub-themes were gathered under the main theme of "Use of educational games in teaching writing". Accordingly, the sub-themes under the main theme and the codes associated with the sub-themes are presented in Figure 6.

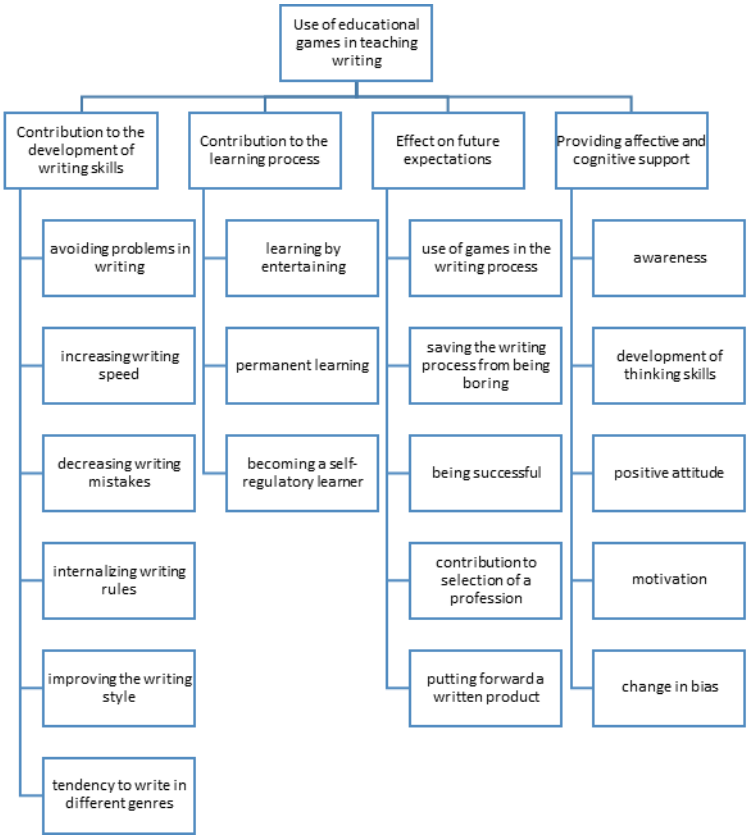

Figure 6. Use of educational games in teaching writing

As seen in Figure 6. the themes of "Contribution to the development of writing skills", "Contribution to the learning process", "Effect on future expectations" and "Providing emotional and cognitive support" were found under the theme of "Use of educational games in teaching writing". The results showed that the use of educational games in writing classes helped to eliminate or reduce writing problems, internalize writing rules, increase writing speed, improve writing style, and encourage participants to write in different text genres (narrative, informational, memoir, biography, etc.) and reduce spelling errors.The use of educational games contributed not only to the development of writing skills but also to the learning process. Other results included the fact that the use of educational games in teaching writing supported learner autonomy, allowed the participants to become self-regulating learners and have fun, and led to permanent learning.

The results showed that the dimensions the participants needed to be supported in teaching writing before the intervention supported the intervention. Besides overcoming the difficulties experienced in the writing process, one of the important results was that the intervention provided the participants with affective and cognitive support. The desirable results included the fact that the participants developed positive attitudes toward learning writing, increased their motivation to write, and eliminated their negative prejudices about the writing process. Moreover, the participants were aware of the development of high-level thinking skills such as imagination, creativity, critical thinking, and empathetic thinking they emphasized throughout the process.

It was seen that educational games also affected the participants' expectations regarding the future of teaching writing. After the intervention, the participants had a high level of expectation about the use of educational games as the boringness of the teaching process was removed. Furthermore, the participants' gains in teaching writing conducted with educational games would allow them to become successful in the future and to put forward written products and would contribute to their choice of profession.

Results Obtained via the Diaries

The results of the analysis of the diaries kept by the study group during the intervention are shown in Figure 7 and Figure 8. Figure 7. shows the sub-themes and the concepts related to the sub-themes emerging within the framework of the main theme of the effect of educational games on the learning process. Figure 8. presents the sub-themes and the concepts emerging within the framework of the main theme of the effect of educational

games on skill development. While the lined arrows shown in the figures indicated the concepts with which the sub-themes were related, the dashed arrows indicated the relations of the concepts with each other.

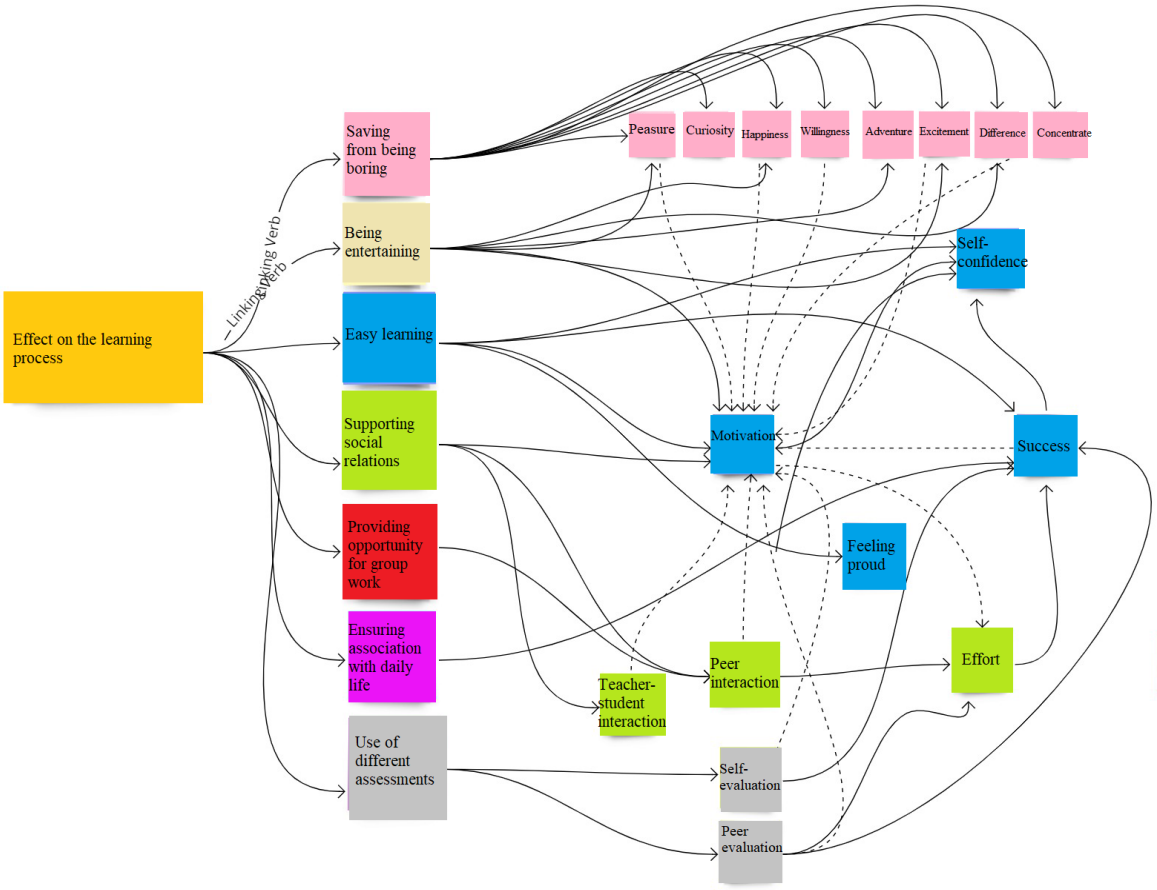

Figure 7. Effect of the educational games on the learning process

When the participants' diaries kept after the intervention of the educational games were analyzed, the sub-themes and concepts were reached within the framework of two main themes. One of the main themes obtained in this respect was the effect of educational games on the learning process, as can be seen in Figure 7. According to the participants' diaries, the writing activities based on educational games had a number of positive effects on the students. The educational games used in the Turkish Language class made the teaching process more enjoyable by preventing boredom; the students enjoyed this process and felt excitement and enthusiasm for the activity and lesson; their sense of curiosity grew; and the games helped them be present.

A further contribution of educational games to the teaching process was that they facilitated learning, supported social relationships in the teaching process, provided opportunities for group work, helped establish an association with everyday life, and supported the use of alternative assessments such as peer- and self-evaluation.. When the concepts related to the sub-themes mentioned above were examined, it was seen that the participants were in positive interaction with their peers and teachers during the teaching process; that they made an effort to maintain this interaction and the process; that this effort led them to success; and that in relation to these all, their self-confidence and motivation increased in internal, external and environmental respects.

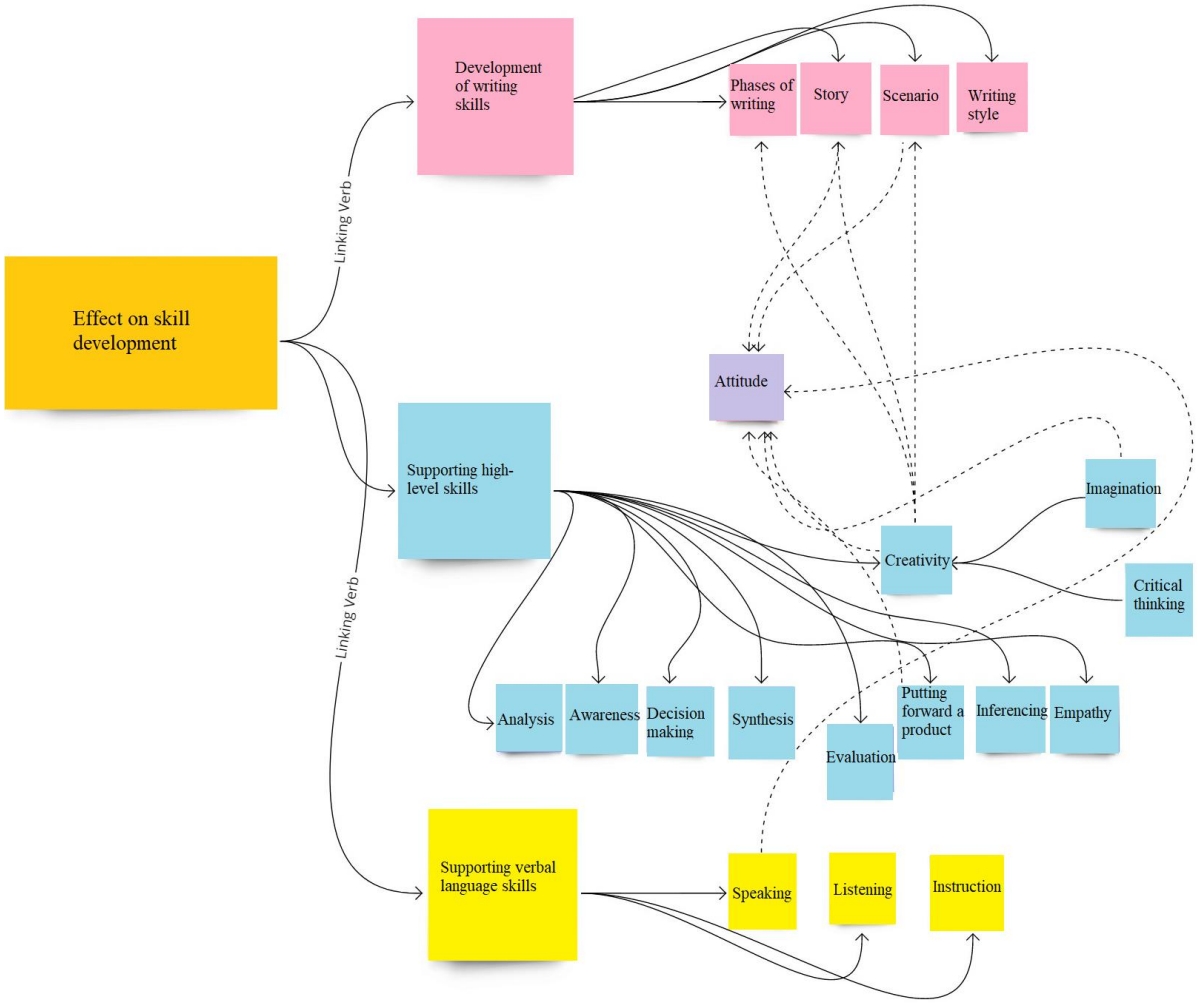

Figure 8. Effect of the educational games on skill development

The second theme reached as a result of the analyses of the participants' diaries was the theme of effect on skill development. The educational games employed in the teaching process supported the development of the participants' writing skills in the dimensions of form and phases of the writing process. Another result was related to the support provided for creativity and imagination in creating stories and scenarios among the writing genres.

In addition to supporting the writing skills, some participants' speaking and listening skills were also supported with educational games. It was also remarkable that the participants frequently referred to high-level skills in the diaries and that the participants had a positive attitude towards the concepts emerging within the framework of the sub-themes. In this respect, when the results obtained via the participants' diaries were evaluated from a general point of view, it was revealed that the process of teaching writing conducted through educational games positively affected the participants' motivation and attitudes. Similarly, the researcher's diaries and observation notes demonstrated that the findings supported the results obtained during the research process. Concerning the results obtained, the following notes regarding the attitudes and motivations of the participants were prominent:

"……Their demands for this game were very high. They had a lot of fun playing the game. They didn't have any trouble writing because they knew something about the story they would write. They combined these events, changed and transformed them, and wrote new stories." (Researcher diary-Dice game) "The students were very happy when they saw the map and the dice. They were dying to play. They focused on the statement to be made after the number came out with excitement" (Observation note-Dice game).

"… They waited impatiently for those who had written before them. They read over and over what their friends wrote. They had a lot of fun the activity also helped the students gain values such as group cooperation, teamwork and team spirit… It was very impressive for them to act together …" (Researcher diary-Writing garden game).

"The silence of the video caught their attention. While watching people, it was clear from their facial expressions what they thought they would write" (Observation note-Dubbing game).

Discussion and Conclusion

It is important to apply scientific research methods to solve problems by determining the competencies or deficiencies in language teaching processes. It is valuable both for the development of their students and for the professional development of teachers. Teachers who are especially responsible for the design of practical processes in the classroom, work in collaboration with field experts in language skills that need to be developed in their students. Besides all, the purpose should be to solve class-specific problems through meaningful and enriched instructional designs in the classroom. The reasons mentioned reveal the necessity of studying problem-solving-oriented designs such as action research in teaching processes (Genç-Ersoy & Ersoy, 2021). In this respect, important results were obtained in the study regarding providing affective support and skill development and revealing the effect of problem-solving approaches to avoiding probable problems.

In the study, several important results were obtained via the approaches employing both quantitative and qualitative paradigms. The quantitative results showed that the participants' post-test mean scores in the dimensions of attitude, motivation, and writing skill development due to the use of educational games in the writing teaching process were higher than their pre-test mean scores. Accordingly, educational games increased the participants' motivation and attitudes towards writing and their success in writing skills. The results were quite valuable considering the contribution of positive attitudes towards writing (Graham, Berninger & Fan, 2007) and motivation to write (Schunk & Zimmerman, 1994) to the success in and development of writing. In terms of the effect of educational games on writing attitude, the results were parallel to those obtained by Erol, Erdem, and Akkaya (2021), Kara and Akın (2018), Liu et al. (2021) and Stojković and Jerotijević (2011), while the results were inconsistent with those reported by İnal and Korkmaz (2019).

The results that educational games contributed to the development of the student's writing skills were consistent with those obtained in applied studies in the literature (Alparslan, 2019; Ayık, 2019; Batur & Özdil, 2018; Özkara & Alparslan, 2019; Uçar & Kan, 2020). Similarly, the results regarding the dimension of the effect of educational games on motivation in writing were parallel to those reported by Ayık (2019), Graham (2006), and Yavuz and Okur (2021). In this respect, consistent with the related literature, the research results showed that the educational games designed for writing support the development of writing skills by increasing individuals' motivation and attitudes towards writing.

When the qualitative results were evaluated, the effect of affective factors on the participants' making sense of the writing process was remarkable. One important result was that previous failure in writing caused reluctance, anxiety, dislike of writing, lack of self-confidence, stress factors, negative attitude towards the writing process, and lack of motivation in the future. Undoubtedly, affective factors regarding writing are important predictors of success in writing (Alluhaybi, 2015; Amiri & Saeedi, 2017; Sarkhoush, 2013), and students with high anxiety and negative feelings about writing tend to be weaker writers (Cheng, Horwitz & Schallert, 1999; Faigley, Daly & Witte, 1981). Moreover, positive attitudes towards writing are exhibited by better writers (Knudson, 1991). Therefore, the purpose should primarily be to eliminate negative situations by determining affective factors in making sense of the writing process. In this study, negative life experiences, which are effective in making sense of the writing process, evolved positively in line with the intervention. The results also showed that participants found writing easier than before the intervention, developed a positive attitude, lack of self-confidence was replaced by self-confidence, felt dislike for writing was replaced by love for writing, dislike and boredom were replaced by fun and entertainment, and their attitude and motivation increased.

According to the results, among the problems encountered by the participants in the writing process before the intervention of the educational games was the difficulties in organizing thoughts, choosing words due to insufficient vocabulary knowledge, and long and difficult writing tasks given above the potential. Students are supposed to organize their ideas to write on a particular subject, and they are also expected to formulate and transfer their ideas in linguistically correct ways (Zimmermann, 2000) and to use appropriate words in this transfer. Undoubtedly, any negativity in these stages will affect the entire writing process. In this respect, controlled writing, guided writing, recreating a written text, free writing, note taking, summarizing, and other techniques could be used to prevent writing problems by considering the cognitive factors in the writing process. Having expectations above the student's level in the writing process may cause them to have difficulties in having a writing purpose and transferring their competencies to the writing process. Students should always be at the center of the writing activity. Accordingly, in the writing process, students should be presented with clear and meaningful situations that will motivate them to write within the framework of topics that students are

not unfamiliar with by taking into account the principles of teaching writing appropriate to the characteristics of student development (Tama & Mc Clain, 1998). Allowing students to make choices according to their interests and needs among the offered options can help solve these problems. The result that the students tended to agree that writing was more fun when they could choose the topic (Clark & Douglas, 2009) also supports the aforementioned suggestion.

In order to help participants overcome the obstacles they encountered in the writing process and improve their writing skills, the research revealed that the writing process should be fun by eliminating boredom, arousing enthusiasm, making you happy, being enjoyable, providing opportunities for group work, providing instructions and examples in the writing process, providing an environment conducive to writing, allowing time to think and rest, and providing students with writing prompts. The training of individuals who can easily express their thoughts and feelings in a fluent manner, who enjoy writing, and who view writing as a profession is facilitated by instructional environments that increase students' motivation to write and positively influence their writing abilities. In an effective writing process, students tend to write freely, without being under pressure, in a classroom environment where there is mental and emotional comfort, away from the fear of being judged and exposed to negative criticism (Takımcıgil Özcan, 2014). In this respect, the processes supported by educational games also used in the intervention have the potential to contribute to the establishment of these learning environments. In fact, this view was supported by the participants who thought that writing processes supported with educational games were beneficial in terms of ensuring learning with fun, developing thinking, and writing skills, and providing emotional support. Moreover, when the needs indicated by the research results and the results obtained via the writing practices supported by educational games were evaluated together, it was seen that the participants' needs in overcoming their writing problems were met.

In other words, in the context of improving writing skills, it was observed that, in addition to learning with enjoyment, the participants were able to write more easily; that they could receive emotional support such as motivation, attitude, self-efficacy, and self-confidence with the learning process and development in question; that the necessary thinking skills were supported; and that the instances of difficulty in the writing process decreased or disappeared.

When the results of the study were evaluated from a broad perspective, it was determined that the process of teaching writing with educational games helped overcome the difficulties encountered by fourth-grade students in the writing process; that the intervention provided the participants with emotional and cognitive support; that their writing skills improved; and that their writing attitude and motivation increased. In this regard, the research results demonstrated that educational games are an effective method for fostering writing skills, eradicating writing issues, and cultivating a positive attitude and enthusiasm for teaching writing.

Recommendations

The results of this study are limited by the instruments, educational games, the study group, and the academic year in which the research process was realized. Teachers could use educational games to teach writing, design the teaching process by determining what cognitive and emotional factors work well in the writing process, give more time to writing by determining what students need and what problems they are having with writing, and use various writing techniques with individual and group work in instructional environments that use educational games. In addition, future studies could be conducted to determine the effects of educational games on developing other language skills. The present study, whose study group included elementary school 4th-grade students, could be replicated with different research samples.

Author (s) Contribution Rate

The authors contributed equally throughout the research process.

Conflicts of Interest

The authors declare that there is no conflict of interest between them.

Ethical Approval

Approval for this study, dated 28.12.2020 and numbered 2020/11, was received from the Human Research Ethics Committee of the university that the first author was responsible for.

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The Relationship Between Problem-solving Skills, Burnout Levels and Self-Efficacy Beliefs of School Principals

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The Relationship Between Problem-solving Skills, Burnout Levels and Self-Efficacy Beliefs of School Principals

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Abstract

This research aims to determine the relationship between school principals' problem-solving skills, burnout levels and self-efficacy beliefs. A quantitative relational design was used in the study. The sample of the research consists of 224 school principals working in Balıkesir. In the research, "Problem-solving Inventory", "Freidman School Principals Burnout Scale" and "School Principals' Efficacy Perceptions Scale" were used as the data collection tools. Data were analyzed by T-test, Single-factor Analysis of Variance (ANOVA), and structural equation modeling. In the research, it was found that school principals' problem-solving skills were at a high level and they almost never experienced burnout and their self-efficacy perceptions were at a high level. The results of the study revealed that there was no significant difference between principals' problem-solving skills, burnout levels, and self-efficacy beliefs and variables such as gender, experience as a principal, and school level. In the study, there was also a low and negative correlation between principals' problem-solving skills and self-efficacy beliefs, self-efficacy beliefs and burnout level, and there was a positive and low relationship between principals' problem-solving skills and burnout level.

Keywords: Problem-solving skills, Burnout, Self-efficacy, School principal

Introduction

Like any other organization, schools are institutions with unique management systems and practices that evolve from interactions, relationships and values with their stakeholders (O'Brennan et al., 2017). Schools have many problem areas such as students, staff, parents, and the school culture. It is very important for school principals to solve the problems that may be experienced in any of these areas. There are often several possible ways to solve problems and successful leaders are expected to identify alternative solutions and find the appropriate solutions (Visone, 2018).

Problem-solving is an important factor for organizations. As in every organization, there are various problems in schools and the greatest responsibility for the solution of these problems falls on the school principals. The principal is primarily responsible for achieving the school's goals and success. School principals are expected to choose the best solution to the problems they encounter among many different options and produce the best solution under any circumstances. In order for this expectation to be fulfilled, the problem-solving skills of school principals must be developed (Aslanargun & Bozkurt, 2012; Güçlü, 2003; Khan et al., 2012; Konan, 2013).

In evaluating problem-solving skills in school administration, if the principal, teachers, parents, students, and community do not work well together, and if the school building, furniture, teaching resources, and garden are not well used, the school's work cannot produce efficient results. The management of all these can be achieved through overcoming the problems systematically and without any problems. In this respect, problem-solving skills, in which all the variables mentioned above can be handled together but in an appropriate order, have an important place in school administration (Akça & Yaman, 2009). Problem-solving is about overcoming the undesirable situations, obstacles and difficulties encountered in reaching a goal (Tekin & Akın, 2021). Inadequacy, tension and psychological disorders can be seen in individuals with poor problem-solving skills (Heppner & Petersen, 1982). According to Bingham (2004), solving problem-solving is a process that requires effort to eliminate the difficulties encountered to reach a certain goal. Individuals who can solve their problems

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have more self-confidence in decision-making, and they are more sociable in social interactions and have a positive self-perception (Şahin et al., 1993). On the other hand, people who consider themselves unsuccessful in problem-solving have more internal conflicts, are hypersensitive in interpersonal relations, have negative self-perceptions, and display hostile behaviors (Dixon et al., 1991). These and similar situations can cause the feeling of burnout in school principals.

It has psychological effects such as burnout, low morale, absenteeism, and being late to work. People who experience burnout develop negative sense of self and attitudes towards work. Their feelings and interest towards the people they work with become dull. People with burnout display indifferent and aggressive behaviors towards the people they serve and their employees (Malakh-Pines & Aronson, 1988). In addition to individual factors, organizational factors such as workload, control, rewards, co-workers, justice and values cause the differentiation of employees' burnout levels (Leiter & Maslach, 2005).

Burnout combines a negative attitude towards one's teaching performance with a decreased sense of personal self-efficacy: In this case, the perception of not reaching the set goals is accompanied by a deep sense of inadequacy (Gastaldi et al., 2014). Freudenberger (1974) defined burnout as the state of exhaustion resulting from failure, exhaustion, loss of energy and performance, and unmet demands; Friedman (2002) defined it as physical or emotional exhaustion, a sense of personal and professional failure, and a strong sense of depersonalization toward those served; Maslach and Jackson (1981) defined it as emotional exhaustion of the individual, an increase in his depersonalization, and a decrease in personal performance. For Maslach, Schaufeli ve Lieter (2001) burnout is being exposed to stress and emotional tiredness in the organization for an extended period of time while Malakh-Pines and Aronson (1981) defined it as a state of physical, emotional and mental exhaustion that occurs in the individual due to long-term exposure to emotionally challenging situations.

The quality of school education is directly related to the good management of schools. Successful management requires school administrators to be mentally and physically healthy, besides many qualifications that they should have. One of the factors that is emphasized and closely affects the mental health of school administrators is the level of burnout (Izgar, 2003). Burnout can occur in any field as well as in a professional sense. Every job has its difficulties, which can cause fatigue and boredom in people from time to time. When these feelings do not interfere with the people's responsibilities, they can cope with this situation more easily. However, if these short-term feelings gradually increase and the individual becomes unable to cope with them, burnout begins to occur. Burnout, if it lasts for a long time, can cause psychological problems and damage the individual's professional life and social resources (Capel, 1991). School principals can achieve professional success by cooperating with all stakeholders in realizing the school's mission. Students, staff, parents, organizational processes, and political processes are important factors in achieving this success. As a result of the negative experiences against these factors, principals may perceive their leadership skills as inadequate. In this situation, school principals may experience a sense of professional and personal failure and stress, and they may probably experience burnout (Friedman, 2002).

Another factor that is as important as problem-solving skills and burnout feelings for school principals in fulfilling their principal duties is self-efficacy beliefs. Self-efficacy belief affects the individual's attitude towards their profession, which affects the individual's professional success and increases the efficiency of the individual's work. As in every profession, educational institutions should ensure this success and efficiency. Self-efficacy beliefs of school principals, which are one of the building blocks of educational institutions, are extremely important in ensuring this success and efficiency. Self-efficacy belief is the individual's self-expression to reveal to what extent they can or cannot achieve that competence in line with their own beliefs, attitudes and experiences when it cannot be directly observed (Schunk, 1990). Self-efficacy is understood as an individual's belief in their strength and whether they can do something by interpreting their own competences (Köybaşı & Dönmez, 2017). Gist and Mitchell (1992) defined it as an estimate of one's capacity to regulate performance on a particular task while Bandura (1997) defined it as a person's belief that they can successfully complete a particular task. Zimmerman (1995) defined it as the self-evaluation of individuals about their ability to perform a job and succeed.

A principal's sense of competence is the judgment about his abilities to structure a particular course of action to achieve desired results in the school he leads. (Bandura, 1997). Principals are seen as a key agent initiating change by raising expectations for both teachers and students. A promising but largely unexplored way to understand the motivation and behavior of principals is the principals' sense of competence. Self-efficacy is a perceived judgment of one's ability to effect change, which can be seen as an essential characteristic of an effective school leader. Principals may feel competent to lead in certain contexts, but this sense of competence may or may not be transferred to other contexts depending on the perceived similarities of the task (Tschannen-

Moran & Gareis, 2004). Another important factor contributing to the effectiveness of school principals is the level of self-efficacy. Self-efficacy is the principal's belief in his abilities. This belief significantly impacts the leadership and success of school principals (Eberhard, 2013).

Job description of school administrators encompasses managing people, the environment, and the program. This position requires knowledge and skills from a variety of disciplines. The success of school administrators in this process depends on their positive perceptions of their self-efficacy for the task. In this sense, school administrators with high self-efficacy beliefs can be more effective and qualified in the school improvement process. In contrast, a person who avoids complex tasks cannot plan to achieve goals, and people who believe in their capacity to achieve goals are people with low self-efficacy. People with high self-efficacy are those who understand their capacities and plan their activities successfully while people with low self-efficacy are those who cannot fulfill their tasks. As a matter of fact, such administrators are expected to be more effective and successful as their schools can directly affect teachers, students and staff (Bandura, 1982; Bandura, 1988; Bandura 1997; Cobanoglu & Yurek, 2018; Dimmock & Hattie, 1996; Lunenberg & Ornstein, 2013).

Educational institutions must lead many changes and developments. School principals have important roles in the effectiveness and continuity of educational institutions in this process. These roles include directing the employees in line with the school's goals, leading the teachers educationally, and having effective communication skills. While school principals play these roles, they encounter various problems within the institution and are expected to solve them effectively. In this way, the employees of the institution feel the power of the principal and see him as a leader. On the contrary, a school principal who experiences burnout and feels inadequate in many aspects in the institution will benefit neither the institution nor the society. This will also affect the school principals' self-efficacy perceptions. Therefore, it is thought that problem-solving skills, sense of burnout and self-efficacy are extremely important concepts for school principals. The analysis of the literature reveals that the relationship between problem-solving skills, burnout levels and self-efficacy factors has not been analysed sufficiently. For this reason, this study aims to determine the relationship between school principals' problem-solving skills, burnout levels and self-efficacy beliefs. For this purpose, answers to the following questions were sought.

- What is the level of problem-solving skills of school principals?
- What is the level of burnout of school principals ?
- What is the level of self-efficacy beliefs of school principals?
- How is there a relationship between the genders of school principals, problem-solving skills, burnout levels and self-efficacy beliefs?
- How is there a relationship between the educational status of school principals and their problem-solving skills, burnout levels and self-efficacy beliefs?
- How is there a relationship between management experiences and their problem-solving skills, burnout levels and self-efficacy beliefs?
- How is there a relationship between problem-solving skills, burnout levels and self-efficacy beliefs of school principals?

Method

Research Design

This study aims to determine the relationship between school principals' problem-solving skills, burnout levels and self-efficacy beliefs. Quantitative relational design was used in the study.

Sample and Population

The research universe consisted of school principals working in official pre-schools, primary schools, secondary schools and high schools within Balıkesir city center in the 2020-2021 academic year. A total of 224 school principals selected by cluster sampling method among 1108 school principals in the provinces and districts of Balıkesir formed the research sample. The analysis of the demographic characteristics of the school principals participated in the research revealed that 77.7% of the school principals were male and 22.3% were female; 10.7% of them worked at pre-schools, 37.9% at primary school, 30.8% at secondary school and 20.5% at high school level. It was observed that 36.6% of them worked for 1-5 years, 30.8% for 6-10 years, 15.2% for 11-15 years, 8.9% for 16-20 years and 8.5% for 21 or more years.

Data Collection Tools

In order to determine the relationship between the problem-solving skills, burnout levels and self-efficacy beliefs, "The Problem-solving Inventory, developed by Heppner and Peterson (1982) and adapted into Turkish by Şahin, Şahin and Heppner (1993), "School Principals Burnout Scale" developed by Freidman (2002) and adapted into Turkish by ve Özer et al., (2012) and "School Principals' Efficacy Perceptions Scale" developed by Tschannen-Moran and Gareis (2004) and adapted into Turkish by Özer (2013) were used. .

Problem-solving Inventory: The Problem-solving Inventory developed by Heppner and Peterson (1982) and adapted into Turkish by Şahin, Şahin and Heppner (1993) was used to determine school principals' problem-solving skills. The original Problem-solving Inventory consists of 35 questions and is a 6-point Likert scale. Due to the adaptation of the scale to the Turkish language, three items were eliminated from the inventory, bringing the total number of items to 32. The Problem-solving Inventory consists of 3 sub-dimensions: confidence in problem-solving ability, approach-avoidance, and personal control. The researcher administered the inventory to 69 school principals who were not part of the sample group as part of the validity and reliability studyCronbach Alpha reliability coefficient of the inventory was .90, KMO value was .76; Bartlett test 1856.138; df: 595 and p= .000. The Cronbach Alpha reliability coefficients for the sub-dimensions of the Problem-solving Inventory are presented in Table 1.

Tablo 1. Cronbach alpha values of the sub-dimensions of the Problem-solving Inventory

	Dimensions	Cronbach Alpha
Problem-solving Inventory	Problem-solving confidence	.88
	Approachavoidance style	.86
	Personal control	.63

In the next step, confirmatory factor analysis was performed for the "Problem-solving Inventory" and the goodness of fit values obtained as a result of the obtained confirmatory factor analysis (CFA) [X2= 989.056; df= 429; X2/df = 2.30; RMSEA= .07; CFI= .80; NFI= .70; GFI= .79; AGFI= .74. When the results of the model are evaluated in general, it is seen that the model has an acceptable fit.

School Principals Burnout Scale: The Freidman School Principals Burnout Scale was developed by Freidman (2002) and adapted into Turkish by Özer et al., (2012). School Principals Burnout Scale is a 5-point Likert-type and consists of 20 questions and 3 sub-dimensions: Burnout, Depersonalization and Professional Success. The scale was applied to 69 school principals outside the sample group within the validity and reliability study scope. Cronbach Alpha reliability coefficient of the scale was .91, KMO value was .81; Bartlett test 834,814; df: 190 and p= .000. The Cronbach Alpha reliability coefficients for the sub-dimensions of the School Principals Burnout Scale are presented in Table 2.

Table 2. Cronbach alpha values of the sub-dimensions of the Freidman School Principals Burnout Scale

	Dimensions	Cronbach Alpha
School Principals Burnout Scale	Exhaustion	.81
	Depersonalization	.93
	Personal accomplishment	.75

In the next step, confirmatory factor analysis was performed for the "Freidman School Principals Burnout Scale" and the goodness of fit values obtained as a result of the obtained CFA [X2= 292,407; df= 156; X2/df = 1.874; RMSEA= .06; CFI= .95; NFI= .89; GFI= .89; AGFI= .85]. When evaluated in general, the model is seen as a good fit.

School Principals' Perceptions of Competence Scale: The Efficacy Perceptions Scale of School Principals, developed by Tschannen-Moran and Gareis (2004), was adapted into Turkish by Özer (2013). It consists of 3 sub-dimensions: Efficacy for Management, Instructional Leadership and Moral Leadership Subscale, and it is a 5-point Likert type scale with 18 questions. The scale was applied to 69 school principals outside the sample group within the validity and reliability study scope. Cronbach Alpha reliability coefficient of the scale was .92, KMO value was .84; Bartlett test 666,988; df: 153 and p= .000. The Cronbach Alpha reliability coefficients for the sub-dimensions of the Efficacy Perceptions Scale of School Principals are presented in Table 3.

Table 3. Cronbach alpha values of the sub-dimensions of the School Principals' Perceptions of Efficacy Scale

	Dimensions	Cronbach Alpha
Efficacy Perceptions Scale of School Principals	Efficacy for Management	.88
	Instructional Leadership	.73
	Moral Leadership Subscale	.77

In the next step, confirmatory factor analysis was performed for the "Freidman School Principals Burnout Scale" and the goodness of fit values obtained as a result of the obtained CFA [X2= 142.268; df= 71; X2/df = 2.004; RMSEA= .06; CFI= .95; NFI= .91; GFI= .92; AGFI= .88]. When evaluated in general, the model is seen as a good fit.

Data Analysis

In the data analysis process, Kolmogorov-Smirnov and Shapiro-Wilk Tests were used to check whether the data showed normal distribution. When the Skewness and Kurtosis values of the data obtained from the Problem-solving Inventory, Freidman School Principals Burnout Scale and School Principals' Perceptions of Efficacy Scale were examined, was observed that the data were normally distributed. The data obtained from the research; T-test, One-factor Analysis of Variance (ANOVA), and structural equation modeling were used.

Results

In the first sub-problem of the research, the answers given by the school principals to the Problem-solving Inventory were analyzed and the results are presented in Table 4.

Table 4. Mean and standard deviations of the problem-solving inventory

Dimensions	n	$\bar{x}$	**s**
Problem-solving confidence	224	1.96	.63
Approachavoidance style	224	2.17	.63
Personal control	224	2.56	.46
Total	224	2.16	.53

Analysis of the data obtained from Table 4 reveals that the problem-solving skills of school principals are at "mostly" ($\bar{x}$=2.16, s=.53) level. When the perceptions of the school principals on the dimensions constituting their problem-solving skills are examined, school principals Confidence in Problem-solving Ability ($\bar{x}$=1.96, n=.63); Approach-Avoidance ($\bar{x}$=2.17, s=.63) and Personal Control ($\bar{x}$=2.56, s=.46) were at the "mostly" level.

In the second subproblem of the study, the burnout scale responses of the school principals were analyzed, and the results are presented in Table 5.

Table 5. Mean and standard deviations of the burnout scale

Dimensions	n	$\bar{x}$	s
Exhaustion	224	1.71	.61
Depersonalization	224	2.02	.92
Personal accomplishment	224	2.25	.74
Total	224	1.95	.64

Analysis of the data obtained from Table 5 are suggests that school principals' responses to the statements in the burnout scale are at the level of "rarely" ($\bar{x}$=1.95, s=.64). When their perceptions regarding the dimensions, namely Exhaustion, Depersonalization and Professional Achievement constituting the burnout scale are examined, it is found that they never experienced burnout in Exhaustion dimension($\bar{x}$=1.71, s=.61), and rarely experienced burnout in Depersonalization ($\bar{x}$=2.02, s=.92) and Professional Achievement dimensions($\bar{x}$=2.25, s=.74).

In the third sub-problem of the study, the answers given by the school principals to the Efficiency Perceptions Scale were analyzed and the results are presented in Table 6.

Table 6. Mean and standard deviations of the school principals' perceptions of competence scale

Dimensions	n	$\bar{x}$	s
Efficacy for Management	224	4.12	.56
Instructional Leadership	224	4.03	.54
Moral Leadership Subscale	224	4.20	.52
Total	224	4.12	.48

Analysis of the data obtained from Table 6 demonstrate that the school principals' responses to the statements in the Efficiency Perceptions Scale are at the level of "quite a lot" ($\bar{x}$=4.12, s=.48). School principals' perceptions of the dimensions of Efficacy for Management ($\bar{x}$=4.12, s=.56) and Instructional Leadership ($\bar{x}$=4.03, s=.54) were at the "quiet" degree. It was found that their perceptions of the Moral Leadership Subscale ($\bar{x}$=4.20, s=.52) dimension were at the "very" level. In the fourth sub-problem of the study, whether the problem-solving skills, burnout levels and self-efficacy of school principals differ according to the gender variable was examined with the T-Test, and the results are presented in Table 7.

Table 7. The results of the t-test aimed at determining the difference between the problem-solving skills, burnout levels and self-efficacy of school principals according to the gender variable

	Gender	n	x	Sd	*t*	df	*p*
Problem-solving skills	Female	50	2.11	.52	-.783	222	.434
	Male	174	2.17	.54			
Burnout levels	Female	50	2.07	.69	1.432	222	.154
	Male	174	1.92	.62			
Self-efficacy beliefs	Female	50	4.04	.57	-1.357	222	.176
	Male	174	4.14	.45			

Analysis of the data obtained from Table 7 shows that there is no significant difference between the genders of the school principals' and the problem-solving skills (t= -.783; p > .05), burnout levels (t= 1.432; p > .05) and self-efficacy beliefs (t= -1.357; p > .05). In the sixth sub-problem of the study, whether the problem-solving skills, burnout levels and self-efficacy of school principals differ according to the principal's experience variable was examined with the One-Way ANOVA test and the results are presented in Table 8.

Table 8. One-Way ANOVA results to determine the difference of school principals' problem-solving skills, burnout levels and self-efficacy according to the principal's experience variable

	Principal's experience	n	*x*	Sd	F	p
Problem-solving skills	1-5 years	82	2.16	.57	*.538*	.708
	6-10 years	69	2.21	.48		
	11-15 years	34	2.18	.62		
	16-20 years	20	2.11	.52		
	21 years and over	19	2.01	.43		
Burnout levels	1-5 years	82	2.06	.64	*1.521*	.197
	6-10 years	69	1.80	.56		
	11-15 years	34	1.98	.76		
	16-20 years	20	1.96	.71		
	21 years and over	19	1.99	.59		
Self-efficacy beliefs	1-5 years	82	4.08	.41	*.754*	.557
	6-10 years	69	4.18	*.44*		
	11-15 years	34	4.04	*.70*		
	16-20 years	20	4.13	*.52*		
	21 years and over	19	4.18	*.43*		

Analysis of the data obtained from Table 8 shows that there is no significant difference between the managerial experiences of the principals and their problem-solving skills (F= .538; p > .05), burnout levels (F= 1.521; p > .05) and self-efficacy beliefs (F= .754; p > .05).

In the seventh sub-problem of the research, whether the problem-solving skills, burnout levels and self-efficacy of school principals differ according to the school level variable was examined with the One-Way ANOVA test and the results are presented in Table 9.

Table 9. One-Way ANOVA results to determine the difference of school principals' problem-solving skills, burnout levels and self-efficacy according to school level variable

	School level	n	*x*	Sd	F	p
Problem-solving skills	Pre-school	85	2.09	.60	*1.059*	.368
	Primary	69	2.23	.59		
	Secondary	46	2.14	.52		
	High	24	2.25	.44		
Burnout levels	Pre-school	85	1.88	.62	*1.928*	.126
	Primary	69	2.08	.68		
	Secondary	46	1.98	.65		
	High	24	1.79	.52		
Self-efficacy beliefs	Pre-school	85	4.20	.45	*1.547*	.203
	Primary	69	4.08	.48		
	Secondary	46	4.03	*.56*		
	High	24	4.08	*.41*		

Analysis of the data obtained from Table 9 demonstarates that there is no significant difference between school levels and the problem-solving skills of school principals (F= 1.059; p > .05), burnout levels (F= 1.928; p > .05) and self-efficacy beliefs (F= 1.547; p > .05) .

Finally, the relationship between the problem-solving skills, burnout levels and self-efficacy of school principals was examined using the structural equation model, and the path diagram for the model is shown in Figure 1.

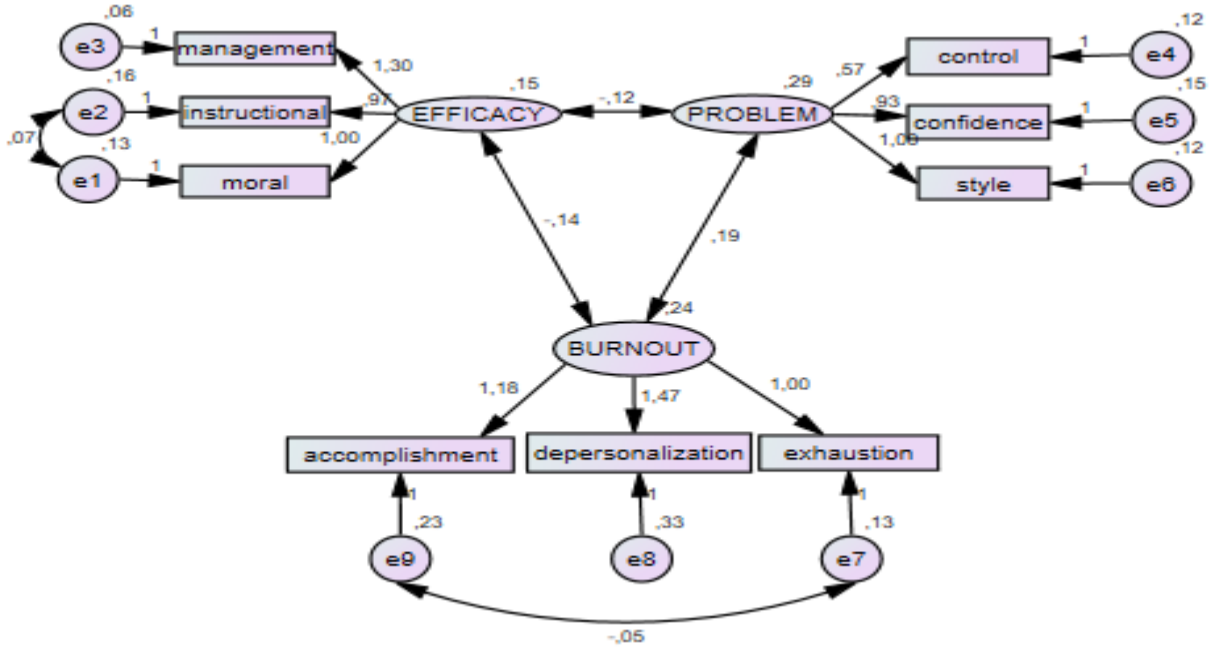

Figure 1. Structural equation model

Figure 1. The structural equation modeling model in which there is a mutual relationship between the decision solving skills, burnout levels and self-efficacy of school principals

The analysis of the model in Figure 1 shows that there is a low and positive relationship between the problem-solving skills and burnout levels (γ= .19) of the school principals. It was also concluded that there is a low and negative correlation between problem-solving skills and self-efficacy beliefs (γ= -0.12), and a low and negative correlation between self-efficacy beliefs and burnout levels (γ= -0.14).

The structural model values of school principals' problem-solving skills, burnout levels and self-efficacy beliefs are shown in Table 10.

Table 10. The Structural Equation Model Results of school principals' problem-solving skills, burnout levels and self-efficacy beliefs

	X^2	df	X^2/df	RMSEA	CFI	GFI	AGFI	NFI
Structural Equation Modeling	49.519	22	2.25	0.07	0.98	0.96	0.91	0.96

According to the path analysis results of the conceptual model in Table 10, the Chi-square fit index of the model (X2= 49.519, df= 22, X2/df= 2.25) was determined to be significant. Other fit indices were found to be RMSEA= .07, CFI= .98, GFI= .96, AGFI= .91, and NFI= .96. It is seen that the model is at a good level in terms of fit values.

Discussion, Conclusion and Recommendations

In the first sub-problem of the research, it is seen that the problem-solving skills of school principals are at a high level. When the school principals' perceptions about the dimensions constituting their problem-solving skills are examined, they stated that their Confidence in Problem-solving Ability, Approach-Avoidance and Personal Control dimensions were at a high level. Today, it is inevitable to encounter some obstacles in the face of rapidly developing technological developments. In order for individuals to overcome these obstacles, they need to know and successfully implement problem-solving methods. The success of individuals is proportional to their ability to effectively solve the problems they encounter. Problem-solving skills of school administrators, who direct and have responsibility for educational activities in educational institutions, affects the education-teaching process and activities directly or indirectly. School administrators should understand the problems of the institution they work in and present effective solutions (Buluç et al., 2011). In this study, it is seen that school principals' problem-solving skills are at a high level. When the previous studies are examined; Akar (2016), Akça and Yaman (2009), Buluç et al., (2011), Güçlü (2003), Karaca and Karaca (2021), Konan (2013) and Kösterelioğlu (2007) reached similar results in their studies. However, Sadıkoğlu (2007), Tokyay (2001), and Üstün and Bozkurt (2000) concluded that school principals have a low level of problem-solving skills.

In the second sub-problem of the research, it was concluded that school principals almost never experienced burnout. When their perceptions of the dimensions constituting the burnout scale are examined, school principals stated that they have never experienced burnout in the dimension of burnout and experienced low levels of burnout in the dimensions of depersonalization and professional achievement. Burnout can occur in any field as well as in a professional sense. Every job has its own difficulties, which can cause fatigue and boredom in the individual from time to time. When these feelings do not interfere with the person's responsibilities, the person can cope with this situation more easily. Unrealistic expectations, when combined with obstacles in achieving goals, complacency, insufficient readiness, and lack of self-confidence, can lead people to burnout (Çınar and Güven, 2019). The burnout experienced in school principals can affect the school's functioning, school climate, organizational commitment, and many similar factors because the roles of school principals are very important in realizing all these factors. As a matter of fact, in this study, it is seen that school principals almost never experienced burnout. Aksu and Baysal (2005) stated that principals experienced burnout in emotional exhaustion and depersonalization dimensions. According to Ellis (1983), Tikkanen et al., (2017), school principals experienced low level of burnout while Aksu and Baysal (2005) stated that school principals have a high level of burnout in the dimension of personal achievement. Dağlı and Gündüz (2008), Daly (1992) and Graf (1996); Özer (2013), on the other hand, reached the conclusion that burnout is experienced at a moderate level.

In the third sub-problem of the research, it was concluded that the school principals' self-efficacy perceptions were at a high level. The perceptions of school principals on the dimensions of Efficacy for Management and Instructional Leadership were high, and their perceptions of the Moral Leadership Subscale dimension were also very high. It was found that school principals with low self-efficacy perceived that they could not control the environment and were less likely to identify appropriate strategies or change unsuccessful ones. When these people face failure, they insist on not changing their behavior, and when they have difficulty, they may try to blame others. School principals with low self-efficacy may not see opportunities, receive support, or adapt. On the contrary, school principals with high self-efficacy do not consider their inability to solve the problems they encounter as a failure. They adjust their personal expectations to suit the circumstances, remain confident and calm, and maintain their sense of humor even in difficult situations (Lyons & Murphy, 1994; Osterman & Sullivan, 1996; Tschannen-Moran & Gareis, 2004), which shows that self-efficacy is an essential factor in ensuring continuity in schools. In the current study, it is seen that the school principals' self-efficacy perceptions are high. When the previos studies are examined; Baltacı (2017b), Bayraktar (2020), Cobanoglu and Yurek

(2018), Işık and Gümüş (2016), İnandı et al., (2015), Karatepe and Uzun (2015), Köybaşı and Dönmez (2017), Okutan and Kahveci (2012) and Özer (2013) reached similar results in their studies. Baltacı (2017a), on the other hand, concluded that school principals' self-efficacy is low.

In the fourth sub-problem of the research, it is seen that there is no significant difference between the problem-solving skills, burnout levels and self-efficacy beliefs of school principals and their gender. The school principal is not an administrator but an orchestra conductor who organizes school activities and designs and shapes the future of individuals and society together with his employees. (Turan, 2018). The school principal needs to be able to solve the problems he encounters in an important task such as leading and managing the school. Many factors affect school principals in performing their duties and solving their problems. The role of school principals is very important in solving the problems faced by interacting successfully with all school stakeholders. Gender factor may also play a role in realizing this role. School principals may need to put a lot of effort into problem-solving. This process may sometimes require working overtime and can be physically exhausting and this may create the perception that male school principals will be more successful. However, in this study, it is stated that gender is not effective in problem-solving skills. When the studies on problem-solving skills are examined; Akça and Yaman (2009), Buluç et al., (2011), Karaca and Karaca (2021), and Tan (2016) reached similar results in their studies.

Today societies are getting more and more complex. Many factors such as changes in social roles, deterioration in interpersonal relations, feeling of loneliness, a competitive work environment, efforts of individuals to prove themselves and high expectations have negative effects on the mental health of employees and this situation causes employees to experience burnout (Dönmez and Güven, 2001). Due to social roles, the efforts of female school principals to fulfill the roles required by school and family life can cause burnout. However, in this study, it was concluded that gender is not effective in experiencing burnout. When the studies on the sense of burnout are examined, Aksu and Baysal (2005), Dönmez and Güneş (2001), Friedman (2002) and Graf (1996) reached similar results in their studies. Ellis (1983) found out that in personal achievement, burnout is higher in men; On the other hand, Izgar (2003) and Ellis (1983) concluded that emotional exhaustion is higher in women.

Many factors that affect the self-efficacy of school principals. One of these factors is gender. It is very important for female school principals to feel competent and ensure the continuity of their self-perception in an important task such as managing the school, which requires them to interact with all stakeholders. In this study, it was concluded that gender is not effective in the perception of self-efficacy. In fact, Bayraktar (2020) stated that women's involvement in business life and their ability to balance their business life and private life over time could explain the lack of difference between the self-efficacy of male and female managers. When the studies conducted with self-efficacy are examined, Bayraktar (2020), Cobanoglu and Yurek (2018), Karahan and Balat (2011), Köybaşı and Dönmez (2017) and Üstüner et al., (2009) have reached similar results in their study. Baltacı (2017b) and Sönmez Genç et al., (2021) concluded in their research that female school principals have a higher level of self-efficacy perception than males.

In the fifth sub-problem of the research, it is seen that there is no significant difference between school principals' problem-solving skills, burnout levels and self-efficacy beliefs and their experience of principalship. Problem-solving skills are very important because people constantly encounter problems in almost every area of life in the developing and rapidly changing social structure. Problem-solving is a complex process in which many cognitive, behavioral, and affective activities are intertwined. Since not all problems are of the same difficulty and complexity, the solution process also differs. A solution can be reached using different strategies such as trial and error, scientific approach, and benefiting from past experiences (Çınar et al., 2009). In other words, the experience of school principals affects their problem-solving skills positively. School principals encounter various problems during their time as principals and strive to solve these problems. It is extremely important for school principals to know how to proceed when faced with similar problems in the future. Despite this situation, the study shows that the experience of principalship is not effective in problem-solving skills. The reason for this situation can be interpreted as follows: school principals can solve the problems they encounter by getting support from other school principals. Ada et al., (2010), Akça and Yaman (2009), Buluç et al., (2011), Graf (1996), Güçlü (2003), and Karaca and Karaca (2021) reached similar results in their studies. Khan et al., (2012) concluded in their study that school principals with higher seniority are more successful in the problem-solving process.

The fact that managers are strongly affected by the emotional demands of the employees and use all their strength to meet these demands can exhaust them emotionally and physically (Dağlı and Gündüz, 2008). It is thought that the school principal who successfully carries out this process will experience burnout less. This is directly proportional to the experience of school principals. However, the current study shows that the

experience of principalship does not have an impact on burnout. When the studies on the sense of burnout are examined, Özer (2013) reached a similar conclusion in his study. Aksu and Baysal (2005), Dönmez and Güneş (2001), and Izgar (2001) concluded that those with low seniority experience more burnout.

As in all organizations, the implementation and success of change in educational organizations is enabled by the participation and support of employees. One of the most important factors influencing employee acceptance of change is self-efficacy beliefs. Individuals with high self-efficacy beliefs are expected to encounter change more naturally (İnandı et al., 2015). School leaders' experiences throughout the school leadership process are expected to influence their self-efficacy beliefs, as school leaders' self-efficacy beliefs contribute to school leadership processes being more effective. It can be said that this situation is related to experience. In the current study, professional experience does not affect school principals' self-efficacy perceptions. When the studies on self-efficacy are examined; Bayraktar (2020), Cobanoglu and Yurek (2018), Demirtaş and Çağlar (2013), Dimmock and Hattie (1996), Gülpınar (2018), Köybaşı and Dönmez (2017), Tschannen-Moran and Gareis (2004) and Sönmez Genç et al., (2021) reached similar results in their study. On the other hand Acat et al., (2011) Baltacı (2017b), Doğu (2016), Kaykı (2019), Gençtürk and Memiş (2010), Say (2005), and Tschannen-Moran and Woolfolk-Hoy (2002) found out that an increase in the seniority of school principals also causes an increase in their self-efficacy. However, Özer (2013) found that among less experienced principals, some had relatively high levels of self-efficacy beliefs.

In the sixth sub-problem of the study, no significant difference was found between school principals' problem-solving skills, burnout levels, self-efficacy beliefs and school levels. Problem-solving skill is one of the important skills that school principals should have. School principals experience various problems at every stage of the education process and try to solve these problems. The presence of problems, the way they arise, and their resolution are likely to be different for each school and each level. The important thing is to be able to solve these problems successfully. Heppner et al. (1985) found that individuals who are unable to solve their problems successfully are insecure and anxious compared to individuals with effective problem-solving skills. They also fail to understand others' expectations and have more emotional problems. Ada et al., (2010), Karaca and Karaca (2021), and Tan (2016) reached similar results in their studies.

All kinds of negative factors that school principals will experience in their schools can affect their burnout, albeit slightly. These negative factors may differ according to the circumstances of time, the developments and the schools' level. As a dynamic and open system, the education system is open to all kinds of external influences. The dynamism of educational organizations can be explained as the ability to adapt themselves to innovations and changes depending on time and circumstances. School principals are also expected to work in dynamic and rapidly changing environments and understand and work in harmony with all stakeholders in this process (Mahfouz, 2018; Uğurlu, 2016). Daly (1992) and Graf (1996) reached similar results in their studies. Friedman (2002), on the other hand, found that middle school principals experience burnout more frequently than primary school principals.

A sense of self-efficacy is an important factor for school principals to be successful in their schools. It is necessary and important that school principals' self-efficacy perceptions should not differ according to school levels. Tschannen-Moran and Gareis (2004) stated that one of the most important factors in motivating principals is the sense of efficacy, and self-efficacy is a perceived judgment of one's ability to influence change, which can be seen as a fundamental characteristic of an effective school leader. When the studies on self-efficacy are examined; Cobanoglu and Yurek (2018), Köybaşı and Dönmez (2017) reached similar results in their study. Unlike the result obtained from this research, Bayraktar (2020) states that administrators working in primary schools have higher self-efficacy perceptions than high school administrators. Similarly, Gülpınar (2018) stated that school administrators working in high schools have lower self-efficacy perceptions than school administrators working in primary and secondary schools. Doğu (2016), on the other hand, concluded that school principals working in primary and high schools have higher self-efficacy perceptions than school principals working in secondary schools.

Finally, in the research, a low level and negative relationship between problem-solving skills and self-efficacy beliefs of the school principals was found. Accordingly, an increase in the problem-solving skills of school principals causes a decrease in their self-efficacy perceptions. Leadership in school management requires first considering the problems realistically and then having some skills to solve them. Real leadership is about confronting the problems courageously and managing them for the benefit of the organization (Bursalıoğlu, 2019). Having problem-solving skills is very important for educational organizations. In the process, school principals deal with various problems that are also independent of each other. It is possible that solving problems will affect the self-efficacy of school principals in a positive way. However, the result obtained in this

research contradicts with the prevous study. The reason for this situation can be explained by the fact that although school principals can solve the problems, they are concerned about not being capable of solving other problems that may arise in the future,

It was concluded that there is a low-level and negative relationship between school principals' self-efficacy beliefs and burnout levels. Accordingly, school principals' self-efficacy beliefs reduce their burnout a little bit. Managers should have high self-efficacy beliefs to solve problems. Low self-efficacy beliefs may cause internalization of failure, behaving formally with employees, and giving more weight to supervision and control. In other words, individuals act according to what they expect to happen and the degree to which they value the result. Expectations are based in part on an individual's ability beliefs. As a result, self-efficacy plays an important role in person's goals based on their perceptions of ability (Celep, 2000; Lovell, 2009). When the studies between self-efficacy beliefs and burnout levels are examined, Federici and Skaalvik (2012) found a negative relationship between principals' self-efficacy and burnout and Özer (2013) concluded that there is a moderate and negative relationship.

It was concluded that there is a low level and positive relationship between the problem-solving skills of school principals and their burnout levels. Based on these results, it can be argued that the increase in the school principals' problem-solving skills also causes an increase in their feelings of burnout. The feeling of burnout is generally accepted as a situation that can affect all employees. Employees in organizations feel exhausted due to their routine work, the intensity of their work and many similar reasons. Experienced burnout will cause low productivity and motivation. Such negative situations experienced by employees will cause the organization not to reach its goals and turn into an inefficient structure. Therefore, it is very important to identify and eliminate the causes of problems that cause employees to experience burnout (Uslu and Acar, 2020). School administrators experiencing burnout are likely to have difficulties in focusing and solving problems. In addition, the existence and continuity of school problems in schools can be seen as an undesirable situation for school principals. Although school principals can solve these problems successfully, dealing with problems and devoting a large part of their time to solving problems may cause an increase in the sense of burnout in school principals, which bears similarities with the results of this study. When the studies between problem-solving skills and burnout levels are examined, Akça and Yaman (2009) concluded that as school principals' perceptions of their problem-solving skills decrease, their emotional exhaustion increases.

In future research, comparisons between private and public-school principals will be possible. In this study, there was a negative correlation between problem-solving skills and low-level self-efficacy beliefs among school principals and a positive correlation between problem-solving skills and low-level burnout. In future studies, interviews can be used to determine the causes of this situation.

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Ethical Approval (only for necessary papers)

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Trends of Game-Based Learning in Mathematics Education: A Systematic Review

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Trends of Game-Based Learning in Mathematics Education: A Systematic Review*

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Abstract

Teaching mathematics through games is one of the most preferred methods in mathematics education today, just as it was in the past. For this reason, studies discussing the concepts of mathematics education and games are proceeding with increasing momentum. In this study, research studies conducted between 2017-2021 on games and mathematics teaching were analyzed using qualitative methods within the framework of certain criteria, and the trend shown by the studies was determined. In this way, a guide for future studies was also provided. For this reason, the study was conducted using a systematic review approach. Within the scope of the study, 80 research studies were examined. As a result of the research, it was seen that the most publications were made in 2019 and were of the article type, that studies aimed at determining effect gained importance, and that in the methodological context, quantitative studies were frequently preferred and experimental designs were used accordingly. It was also found that secondary school students were preferred as participants, that the most common type of game used was digital computer games, that the games were mostly associated with the learning area of "numbers and operations," and that the research studies had mostly positive results for the use of games in mathematics education.

Keywords: Game, Game based learning, Mathematics education, Systematic review

Introduction

Constructivism in education emerged after the behavioral approach as an approach that focuses on the active learner in the learning-teaching process, draws attention to the previous beliefs, knowledge and skills possessed by the individual, and reveals the pleasant and stimulating perspective of learning. However, constructivism's greatest contribution to education is the argument that knowledge as a product can be created through a process (Jones & Brader-Araje, 2002). In this regard, constructivist theory assumes that students in mathematics classrooms create mathematical knowledge themselves by going through a series of mental processes and using their prior knowledge. For example, while teaching division in a constructivist classroom environment, when you expect a student to answer the question, "How many groups of 5 can be made from the number 100?" the student should use the subtraction and multiplication operations from their previous knowledge. This is an indication of how the constructivist approach is reflected in mathematics teaching (Van de Walle, Karp & Bay-Williams, 2016). Along with this approach, Prince (2004) presented active learning as a model in which meaningful learning activities occur and students proceed by knowing what they are doing and how they are doing it. One method of teaching with games can be used in the student-centered active learning approach, where individual differences are taken into account and individuals can freely ask questions and discuss them.

The history of games is as old as human history itself. Almost every society in history has incorporated games into their daily lives (Wells, 2012). Moreover, from past to the present, mathematicians have created many games, such as Cardano's Rings (Chinese Rings), the Tower of Hanoi by Lucas, and the Hungarian Ernö Rubik's Cube (Uğurel & Moralı, 2008). In this respect, it is possible to say that there is a relationship between the game's concept and mathematics. Indeed, according to Foster (2004), the best way to involve students in mathematics activities is to allow them to make connections between games and their world. It is not easy to say how mathematical a game is (Silva, 2011); however, the mathematical game can be expressed as a type of

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mathematical problem (Winicki-Landman, 2008). The mathematical game has a challenge, a set of rules, and specific mathematical cognitive goals (Oldfield, 1991). However, it should be ensured that students properly understand important issues such as the way a mathematical game should be played, the situation of the class and the design of relationships between students during the game, as well as the students' ability to understand the game and the duration of the game, and these issues should be properly explained (Usta et al., 2017).

When examining the studies that use the method of teaching with games, it was found that teaching with games increases academic achievement (Liang, Zhang, Long, Deng & Liu, 2019; Rawansyah, Pramudhita & Pramitarini, 2021; Rondina & Roble, 2019) and positively affects attitudes toward mathematics instruction (Chiang & Qin, 2018; Tuekle, 2020), and that research participants positively evaluate the use of games in mathematics instruction (Bragg, 2007; Koç-Deniz, 2019; Russo, Bragg & Russo, 2021; Watson-Huggins, 2018).Along with the increase in studies conducted on teaching mathematics with games in recent years, compilation studies are also encountered (Divjak & Tomić, 2011; Joung & Byun, 2020; Türker & Arslan, 2021). Divjak and Tomić (2011) analyzed 32 studies conducted between 1995 and 2010, in which an attempt was made to determine the effect of games on motivation and achievement of learning goals in mathematics education through the use of mathematical computer games. While the studies conducted in Turkey on teaching mathematics with games are discussed in the study made by Türker and Arslan (2021), content analysis is carried out for digital mathematical games in the 12th grade mathematics curriculum in the study by Joung and Byun (2020). Türker and Arslan (2021)' study was limited to between 2002-2017. When we examine it, we do not know the trend in the last five years. Hence, a new discourse is needed on this subject. Divjak and Tomić (2011) focused on mathematical computer games' effects on mathematic teaching. Their study didn't include educational games (card games, puzzles, board games, etc.) that affect in mathematics teaching. Joung and Byun (2020)' studies, on the other hand, contained limited to analysis based on NCTM standards. Since our study covers the years 2017-2021, it is more up-to-date than previous studies. In addition, mathematics education studies that contain both computer games and educational games are included in the research.

The number of systematic reviews has increased steadily in the last two decades, while there are significant benefits compared to conventional reviews in terms of examining all the available data (Bown & Sutton, 2010). In this study, it is thought that the systematic discussion of the recent studies on teaching mathematics with games on an international scale will guide the researchers who work in this field. In this context, this study aims to examine the research studies conducted between 2017-2021 on the use of games for mathematics education or teaching in terms of various variables. In line with the aim of the study, answers to the following research questions were sought:

- How are the conducted studies distributed in terms of type and years?
- What is the distribution of the studies carried out at national and international level?
- What are the purposes of the conducted studies?
- Which methodologies and designs are used in the conducted studies?
- How are the types and numbers of participants in the conducted studies distributed?
- What types and number of games were used in the studies conducted, and to what areas of learning do the games relate?
- What are the data collection tools, data analysis types, and validity and reliability methods used in the conducted studies?
- What do the results of the conducted studies reveal?

Method

Research Design

A research approach that comprehensively and in detail scans studies conducted using similar methods in a field, identifies studies to be included in the review using various selection criteria, and conducts a structured and comprehensive quality assessment of the identified studies and synthesis of their findings is referred to as a systematic review (Gough & Thomas, 2016; Higgins et al., 2019).A systematic review is the science of identifying, selecting and synthesising primary research studies in order to provide a comprehensive and reliable picture of the subject under examination (Oakley, 2012). As a form of research, systematic reviews bring together what is known in the research literature by using transparent and accountable methods (Cooper, Hedges & Valentine, 2019). In this way, the topics that need to be researched in the future and the gaps or areas that are insufficient in the literature can be identified. In this study, the research studies conducted between 2017-2021 on games and mathematics teaching were analysed with qualitative methods within the framework of certain

criteria. It was determined what kind of a trend the studies showed. In this way, a guide for future studies is also provided. For this reason, the study was conducted in accordance with the systematic review approach.

Data Collection Process

Data collection for the study lasted from October 10, 2021, to January 1, 2022.In the data collection stage of this study, the systematic review study criteria of Bown and Sutton (2010) were taken as reference. Accordingly, the subject of the study was determined as "the use of games in mathematics education". The keywords to include this subject were determined as "matematik ve oyun", "matematiksel oyun", "eğitsel matematik oyunları", "mathematics and game", "mathematical game", "math game", and "educational mathematics game". With these words, the "Google Scholar", "Wiley", "Eric", "Web of Science", "ASOS", "ULAKBİM", "SOBİAD", "YOK National Thesis Centre" and "ProQuest" databases were scanned by both researchers. As a result of this scan, 176 studies were accessed. These studies were examined according to the criteria that they were conducted between 2017and 2021, were written in Turkish or English, were written by local or foreign authors, and related to the use of games in mathematics teaching or education. As a result of this examination, it was seen that there were 80 studies that met the criteria of the study to be conducted. Other studies were excluded because they did not meet the criteria of the study. The studies included in the scope of the research consist of 8 conference papers, 47 articles, 17 master's theses and 8 doctoral theses. The identifier and code information used in the analysis process according to the types of the examined studies are presented in Table 1.

Table1. Identifier, type and code information of reviewed studies

Conference Papers	Codes
Ergül & Doğan (2019)	PT1
Er et al. (2019)	PT2
Yıldız-Durak (2019)	PT3
Üstün (2020)	PT4
Graceota & Slamet (2021)	PF5
Rawansyah, Pramudhita & Pramitarini (2021)	PF6
Shabrina et al. (2020)	PF7
Akintunde et al. (2020)	PF8
Articles	**Codes**
Usta et al. (2017)	AT1
Pilten, Pilten, Divrik & Divrik (2017)	AT2
Callaghan, Long, van Es, Reich & Rutherford (2017)	AF3
Barreto, Vasconcelos & Orey (2017)	AF4
Kalish (2017)	AF5
Turgut & Temur (2017)	AT6
Heshmati, Kersting & Sutton (2017)	AF7
Boz (2018)	AT8
Usta et al. (2018)	AT9
Aktaş, Bulut & Aktaş (2018)	AT10
Skillen, Berner & Seitz-Stein (2018)	AF11
Yong, Gates & Yee-Chan (2018)	AF12
Chiang & Qin (2018)	AF13
Fouze & Amit (2018)	AF14
Kiili, Ojansuu, Lindstedt & Ninaus (2018)	AF15
McFeetorsa & Palfy (2018)	AF16
Nfon (2018)	AF17
Çalışkan & Mandacı Şahin (2019)	AT18
Doğan & Sönmez (2019)	AT19
Özata & Coşkuntuncel (2019)	AT20
Rondina & Roble (2019)	AF21
Tärning & Silvervarg (2019)	AF22
Liang, Zhang, Long, Deng & Liu (2019)	AF23
Cohrssen & Niklas (2019)	AF24
Yıldız-Durak & Karaoğlan-Yılmaz (2019)	AT25
Saygı & Alkaş-Ulusoy (2019)	AT26
Machaba (2019)	AF27
White & McCoy (2019)	AF28
Ayvaz-Can (2020)	AT29

Gök (2020)	AT30
Gök, İnan & Akbayır (2020)	AT31
Yağmur (2020)	AT32
Deng, Wu, Chen & Peng (2020)	AF33
Bullock et al. (2020)	AF34
Başün & Doğan (2020)	AT35
Bui et al. (2020)	AF36
Es-Sajjade & Paas (2020)	AF37
Lee & Choi (2020)	AF38
Joung & Byun (2020)	AF39
Wouters & Van der Meulen (2020)	AF40
Taja-on (2021)	AF41
Russo, Brag & Russo (2021)	AF42
Dönme, Dönmez, Kolukısa & Yılmaz (2021)	AT43
Baran-Kaya & Gökçek (2021)	AT44
Türker & Arslan (2021)	AT45
Marange & Adendorff (2021)	AF46
Koneva & Shabanova (2021)	AF47
Master's Theses	Codes
Dönmez (2017)	MT1
Türkmen (2017)	MT2
Demirkaya (2017)	MT3
Atasay (2018)	MT4
Sönmez (2018)	MT5
Karamert (2019)	MT6
Çalışkan (2019)	MT7
Gülleci (2019)	MT8
Çubukluöz (2019)	MT9
Yılmaz (2019)	MT10
Galiç (2020)	MT11
Türker (2020)	MT12
Pehlivan (2020)	MT13
Tükle (2020)	MT14
Aksakal (2020)	MT15
Ergül (2021)	MT16
Başkahya (2021)	MT17
Doctoral Theses	Codes
Stanton (2017)	DTF1
Eyster (2017)	DTF2
Akkaya (2018)	DTT3
Watson-Huggins (2018)	DTF4
McIntosh (2018)	DTF5
Koç-Deniz (2019)	DTT6
Galarza (2019)	DTF7
Kokandy (2021)	DTF8

PT: Conference Papers with Turkish Authors, PF: Conference Papers with Foreign Authors, AT: Articles with Turkish Authors, AF: Articles with Foreign Authors; MT: Master's Theses with Turkish Authors, DTF: Doctoral Theses with Foreign Authors, DTT: Doctoral Theses with Turkish Authors.

Data Analysis

In this study, using Aztekin and Taşpınar-Şener (2015) as a reference, two content analysis methods were used together for the data analysis. After performing the descriptive and content analysis of the studies related to games and mathematics education, thematic analysis was carried out to interpret and synthesise the studies in depth (Çalık & Sözbilir, 2014). For this purpose, a thematic analysis matrix was created by the researchers. The data analysis systematics used in the meta-synthesis studies made by Aztekin and Taşpınar-Şener (2015), Divjak and Tomić (2011), Türker and Aslan (2021) were effective in the formation of this matrix. In the thematic analysis matrix created as a result of the research, the type of research, purpose, results, methodology, design, participant type, number of participants, game type, number of games, mathematics learning areas to which the games relate, data collection instruments, types of data analysis, methods used to determine validity and reliability, and information on the national and international scale of the studies correspond to the 15 main

themes created by conducting the content analysis.Observing the main themes in the thematic analysis matrix, the two researchers recorded the results of the content and descriptive analysis of the 80 studies using the Microsoft Excel program. In this process, the researchers' collective opinions on the subthemes were evaluated, which were created a total of 6 times, meeting every 15 days.In addition, this process was checked by a colleague at frequent intervals. As a result of the examinations, 111 sub-themes were found with the common opinion of both researchers and a colleague. The main themes used and the sub-themes that emerged as results of the analysis are presented in Table 2.

Table 2. Information on main themes and sub-themes

Themes	Sub-Themes
Year of Publication	2017-2018-2019-2020-2021
Type of Study	Conference Paper - Article - Master's Thesis - Doctoral Thesis
National and International Scale Information of Studies	Journal Index - Thesis Database - Conference Information
Purpose of Study	Determining Effect - Game Design - Obtaining Opinions - Compiling Previous Studies - Presenting a Theoretical Infrastructure for Relationship between Mathematics and Games
Research Methodology	Qualitative Methodology - Quantitative Methodology - Mixed Methodology - Theoretical Methodology
Research Design	Experimental Designs - Correlation - Survey - Meta-Analysis - Phenomenological Study - Case Study - Meta-Synthesis - Action Research - Convergent Mixed Design - Exploratory Sequential Design - Explanatory Sequential Design - Parallel Conversion Design - Mixed Embedded Design – Design Not Specified
Participant Type	Preschool Students - Primary School Students - Secondary School Students - High School Students - Primary & Secondary School Students - Primary School Students & Primary School Teachers - Secondary School Students & Mathematics Teachers - Preservice Teachers - Parents - Documents - Teachers
Number of Participants	1-20; 21-41; 42-62; 63-83; 84-104; 105-125; 126 or more
Type of Game	Computer Game - Educational Game - Cultural Game - Computer Game & Educational Game
Number of Games	1-5 Games; 6-10 Games; 11-15 Games; 16 or more Games; Not Specified
Mathematics Learning Areas that Games are Related to	Numbers and Operations - Algebra - Geometry - Measurement - Data - Probability - Number Sense - Mathematical Skills - Statistics
Data Collection Tools	Questionnaire - Achievement Test - Interview - Observation - Audio-Video Recordings - Photographs - Skill/Aptitude Tests - Student Activities - Diary Records - Scales - Other - Document - Not Specified
Data Analysis Types	T-test - Mann-Whitney U Test - Wilcoxon Signed-Rank Test - Regression Analysis - Chi-Square - Pearson Product-Moment Correlation - Anova Test - Ancova Test - Descriptive Statistics - Kruskal-Wallis Test - Hierarchical Linear Modelling - Content Analysis - Descriptive Analysis - Z Statistic
Validation Methods	Item Discrimination and Reliability Index - Table of Specification - Expert Opinion - Examples of Previous Studies - Detailed Description of Process - Factor Analysis - Participant Observation - Data Triangulation - Literature Support - Not Specified
Reliability Determination Methods	Test-Retest Method - Intercoder Agreement - KR-20 - KR-21 - Cronbach Alpha - Interrater Correlation - Direct Quotation - Detailed Explanation of Data Analysis and Collection Processes - Data Triangulation - Expert Observation - Not Specified
Research Results	Positive Effect Observed - No Difference Observed - Different Levels of Effect between Variables Observed - Negative Effect Observed – Other (views, attitude, etc.)

In order to provide ease of understanding for the reader, the data collected under the themes and sub-themes in the matrix shown in Table 2 are presented by determining their percentages on the graphs created through the program with which the data were processed. In addition, the frequencies of the studies corresponding to the percentages and the code information for the studies in question are given in the comments below the graphs.

Credibility

The main themes used for the study's credibility (reliability and validity) were determined by considering the literature. Sandelowski, Barroso and Voils (2007) discussed the necessity of researchers to carry out the analysis process by adhering to the method to ensure meta-synthesis validity. This study also ensured that both researchers remained faithful to the thematic analysis matrix during the content analysis process. When analysing qualitative research data, it is recommended that the analyses are checked comparatively (Denzin &

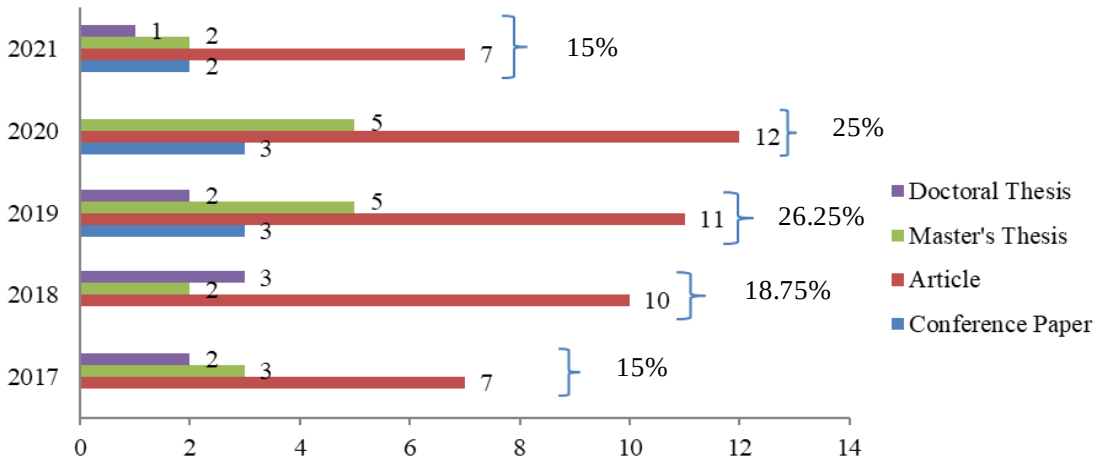
Lincoln, 2011). For this purpose, the researchers came together at certain intervals and shared their ideas about the sub-themes they had created so far. After the sub-themes were determined, the researchers randomly selected one study from each determined main theme and analysed it individually. Following the individual examinations, the data were compared, and it was seen that the researchers agreed with the great majority of the analyses. Moreover, for the validity of the sub-themes that were created, the method of reanalysis of data applied by Kaleli-Yılmaz (2015) was used. For this purpose, one researcher re-coded the data about a month after completion of the data analysis. The consistency between the first and last coding made by the researcher was calculated as 93%. Creswell (2017) also considered it necessary to ensure transparency in qualitative research. For this reason, to ensure their transparency, the documents used in the analysis stage were recorded to preserve them.

Results

The data analyses included under this heading were evaluated in the context of the research questions and are presented accordingly.

Distribution of the Studies by Type and Year

The results of the distribution by year of the 80 studies examined in the study are shown in Graph 1.

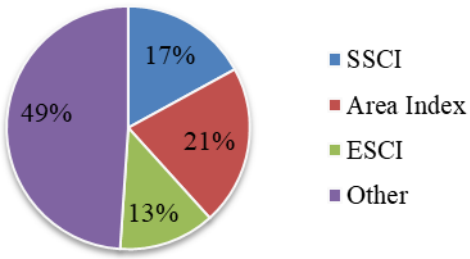


Graph 1. Distribution of the 80 studies

According to Graph 1, it is seen that a total of 12 studies, including 7 articles, 3 master's theses and 2 doctoral theses, were conducted in 2017 (DTF1, DTF2, AT1, AT2, AT6, AF3, AF4, AF5, AF7, MT1, MT2, and MT3). These studies comprise 15% of all studies. A total of 15 studies, comprising 10 articles, 2 master's theses and 3 doctoral theses, were conducted in 2018 (DTT3, DTF4, DTF5, AT9, AT10, AT8, AF11, AF13, AF14, AF15, AF17, AF12, AF16, MT4, and MT5). These studies correspond to a percentage of 18.75%. It can be understood that a total of 21 studies, namely 3 conference papers, 11 articles, 5 master's theses and 2 doctoral theses, were carried out in 2019 (PT1, PT2, PT3, DTT6, DTF7, AT18, AT19, AT20, AT25, AT26, AF21, AF22, AF23, AF24, AF27, AF28, MT10, MT6, MT7, MT8, and MT9). These studies comprise a 26.25% segment. A total of 20 studies, including 3 conference papers, 12 articles and 5 master's theses, were conducted in 2020 (PT4, PF5, PF6, AT29, AT30, AT31, AT32, AT35, AF33, AF34, AF36, AF37, AF38, AF39, AF40, MT11, MT12, MT13, MT14, and MT15). It can be seen that these studies correspond to a percentage of 25% of all studies. It can be understood that a total of 12 studies, namely 2 conference papers, 7 articles, 2 master's theses and 1 doctoral thesis, were carried out in 2021 (PF7, PF8, DTF8, AT43, AT44, AT45, AF46, AF41, AF42, AF47, MT16, and MT17). These studies make up 15% of all studies. According to Graph 1, it can be seen that most of the studies were academic articles. In terms of years, it can be said that most studies belong to the year 2019.

National and International Distribution of the Conducted Studies

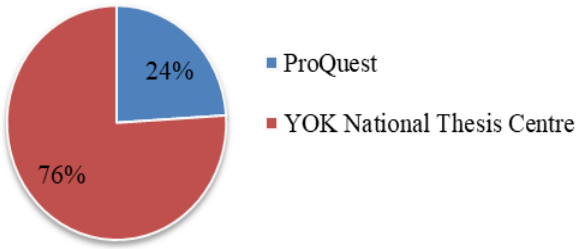
Among the 80 studies examined within the scope of the research, 42 were carried out by local authors and 38 by foreign authors. Among these studies, 47 articles were conducted, 18 by Turkish and 29 by foreign authors. The journal index distributions showing the position of the articles on a national and international scale are shown in Graph 2.



Graph 2. Journal indexes of reviewed articles

According to Graph 2, the articles scanned in other indexes constitute a 48% segment. In this context, it is seen that there are 23 articles (AT9, AT10, AT18, AT35, AT43, AT8, AF14, AF16, AF17, AT1, AF21, AT25, AT26, AF24, AF28, AT29, AF41, AF27, AF39, AT44, AT45, AF46, and AF47). Studies in journals within the scope of the SSCI constitute 17% of all studies. In this context, there are 8 articles (AF11, AF3, AF7, AF13, AF23, AF36, AF37, and AF38). Studies scanned in the ESCI index correspond to a value of 12%. Within this scope, there are 6 articles (AF4, AF5, AF12, AF15, AF22, and AF40). Articles included in the area index correspond to a percentage of 23%. The number of articles evaluated in this context is 10 (AT6, AT19, AT20, AF34, AT30, AT31, AT32, AF33, AT2, and AF42).

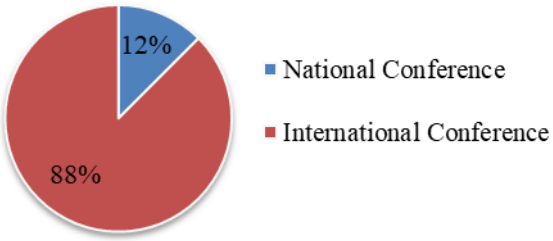
Of the 25 postgraduate theses examined within the scope of the research, 17 are master's theses and 8 are doctoral theses. All of the master's theses belong to Turkish researchers. Two of the doctoral theses were written by Turkish researchers, while 6 of them were written by foreign researchers. The thesis database distributions showing the place of the theses on a national and international scale are as shown in Graph 3.



Graph 3. Databases of reviewed theses

According to Graph 3, 76% of the thesis studies were accessed from the YOK National Thesis Centre database. It can be seen that there are 19 studies within this scope (MT1, MT2, MT3, MT4, MT5, MT6, MT7, MT8, MT9, MT10, MT11, MT12, MT13, MT14, MT15, MT16, MT17, DTT3, and DTT6). The theses accessed from the ProQuest database comprise 24% of all thesis studies. In this context, there are 6 thesis studies (DTF1, DTF2, DTF4, DTF5, DTF7, and DTF8).

The conference information showing the national and international scale of the papers examined within the scope of the research is as shown in Graph 4.

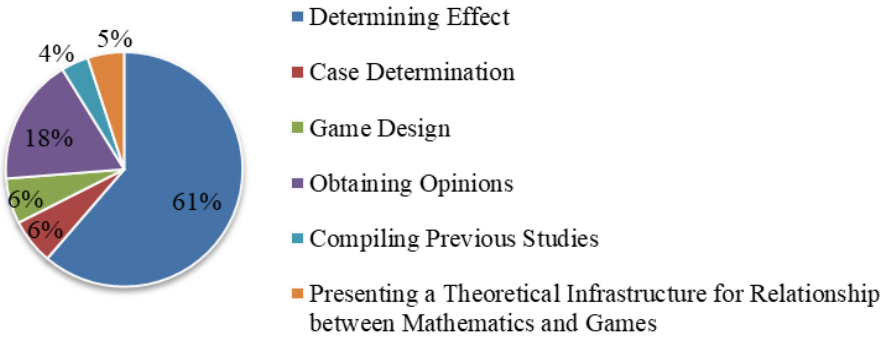


Graph 4. Conference information of reviewed papers

As seen in Graph 4, the papers included in national conferences correspond to a value of 12%. Studies evaluated in the international context constitute 88% of all studies. One paper was presented at a national conference (PT2), while 7 papers were presented at international conferences (PT1, PT3, PT4, PF5, PF6, PF7, and PF8). Of the 8 conference papers, 4 belong to Turkish researchers (PT1, PT2, PT3, PT4), while 4 belong to foreign researchers (PF5, PF6, PF7, and PF8). The 7 papers presented at international conferences are full texts (PT1, PF7, PT4, PT3, PF5, PF8, and PF6). The one paper presented at the national conference is a summary text (PT2). The papers examined within the scope of the research were presented at social sciences conferences, engineering and education conferences, preschool education conferences, education conferences, and at conferences on learning analytics and knowledge with materials science and engineering.

Distribution of the Studies According to their Purposes

The results regarding the purposes of the 80 studies examined in the study are shown in Graph 5.

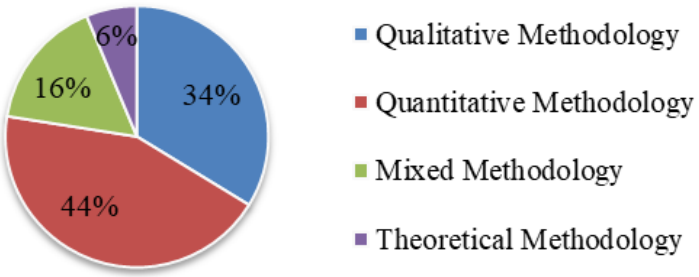


Graph 5. Purposes of reviewed studies

According to Graph 5, it can be seen that 61% of the studies using games in mathematics education were conducted to determine the effect. These studies are 49 in number (PT1, DTT3, DTT6, DTF7, DTF1, DTF2, DTF4, DTF5, DTF8, AT9, AT10, AT18, AT35, AT43, AT8, AF11, AF12, AF13, AF15, AF16, AF17, AF21, AF22, AF23, AF24, AF28, AF34, AF36, AF37, AF38, AF40, AF41, AF4, AF7, MT1, MT10, MT11, MT12, MT13, MT14, MT16, MT17, MT2, MT3, MT5, MT6, MT7, MT8, and MT9). Studies conducted to determine cases accounted for 6% of the total. It was found that 5 studies were performed for case detection (MT4, PF6, MT15, AF46, and AF42). It can be seen that the studies conducted for the purpose of game design have a share of 6%. Five studies aimed to design games that can be used in mathematics education (PF7, PF8, AT2, AT44, and AF47). Fourteen studies were conducted to use games in mathematics education or to obtain opinions about the games used (PT2, PT3, PT4, AT1, AT19, AT20, AT25, AT26, AT29, AT30, AT31, AT32, AF27, and AF33). These studies comprise 18% of all studies. Three studies were conducted to compile previous studies (AT6, AF39, and AT45), making up 4% of all studies. Four studies were conducted to reveal the relationship between mathematics and games (PF5, AF3, AF5, and AF14). These studies constitute 5% of all studies.

Distribution of the Studies According to their Methodologies and Designs

The results related to the methodology of the 80 studies that were examined in the study are shown in Graph 6

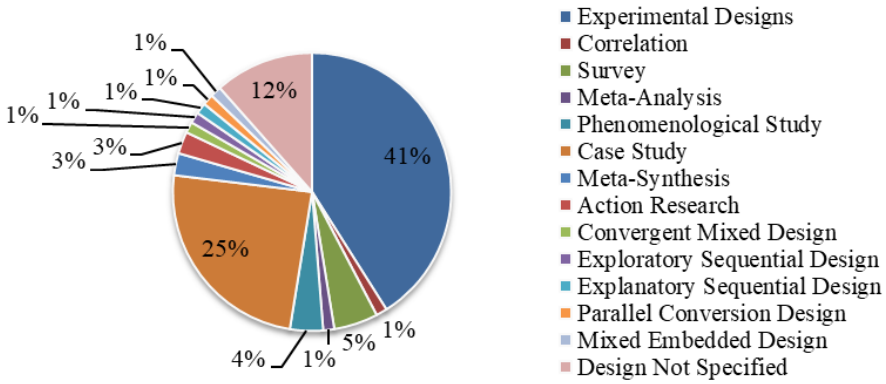


Graph 6. Methodologies of reviewed studies

According to Graph 6, studies conducted with a quantitative method make up 44% of all studies. The number of these studies corresponds to 35 of the 80 studies (PT1, PF5, PF6, DTF1, DTF2, DTF4, DTF5, DTF8, AT9,

AT10, AT35, AT43, AT6, AT8, AF11, AF13, AF15, AF17, AF21, AF22, AF23, AF24, AF37, AF38, AF40, AF41, AF42, MT10, MT12, MT13, MT14, MT16, MT17, MT3, and MT8). Studies using a qualitative method constitute 34% of all studies. Accordingly, 27 studies were conducted with a qualitative method (PT2, PT3, PT4, AT1, AT19, AT20, AT25, AT26, AT2, AT29, AT30, AT31, AT32, AT44, AT45, AF12, AF16, AF27, AF28, AF33, AF39, AF46, AF4, MT11, MT15, MT4, and MT9). Studies using mixed methods comprise 16% of all studies. Accordingly, it is seen that 13 studies are mixed method studies (DTT3, DTT6, DTF7, AT18, AF34, AF36, AF3, AF7, MT1, MT2, MT5, MT6, and MT7). Five studies were evaluated in the theoretical context (justification based on the literature) (PF7, PF8, AF14, AF47, and AF5). These studies constitute 6% of all studies.

The results with regard to the design of the 80 studies examined as part of the study are shown in Graph 7.

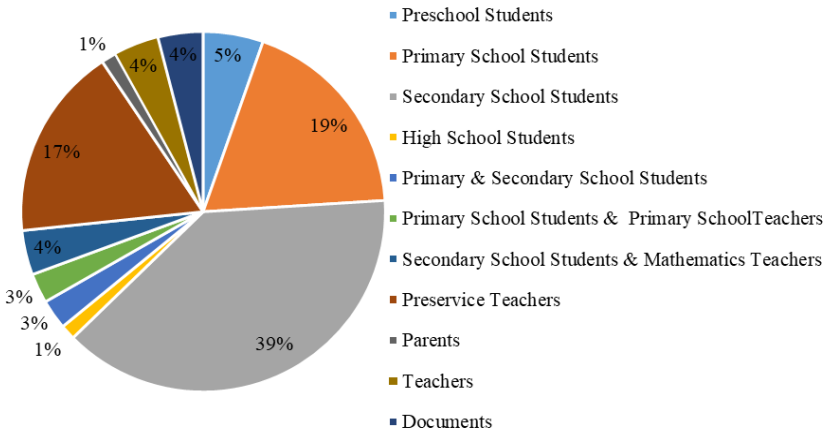


Graph 7. Designs of reviewed studies

According to Graph 7, studies carried out with an experimental design constitute 41% of all studies. Accordingly, it can be understood that experimental designs were preferred in 32 studies (PT1, DTT3, DTF1, DTF2, DTF4, DTF8, AT9, AT10, AT35, AT43, AT8, AF11, AF13, AF15, AF21, AF22, AF23, AF24, AF37, AF38, AF40, AF41, MT10, MT11, MT12, MT13, MT14, MT16, MT17, MT3, MT7, and MT8). Case studies comprise 25% of all studies. Accordingly, 19 studies were conducted as case studies (PT2, PT4, AT1, AT19, AT25, AT26, AT2, AT30, AT31, AT32, AT44, AF14, AF27, AF28, AF33, AF46, AF4, MT15, and MT4). It can be understood that 9 studies do not have design information, with a share of 12% (PT3, PF7, PF8, AT18, AF3, AF47, AF5, AF7, and MT1). Studies using a survey design account for 5% of all studies.Accordingly, 4 studies were carried out with a survey design (PF5, PF6, AF17, and AF42). Phenomenology studies weight 4%. It can be understood that 3 studies are phenomenological studies (AT20, AT29, and AF12). There is 1 study conducted as a meta-analysis study (AT6), which corresponds to 1% of all studies. Two studies were conducted as meta-synthesis studies (AT45 and AF39). These studies constitute 3% of all studies. There is 1 study conducted with a correlational survey design (DTF5), comprising 1% of all studies. One study was conducted using a mixed embedded design (MT21), constituting 1% of all studies. It is seen that there are also single studies using an explanatory sequential design (MT6), a parallel conversion design (AF34), a convergent mixed design (DTF7), and an exploratory sequential design (DTT6). These studies each have a weight of 1% among the studies examined. The two studies conducted with an action research design comprise 3% of all studies (AF16 and MT9).

Distribution of the Studies According to the Type and Number of Participants

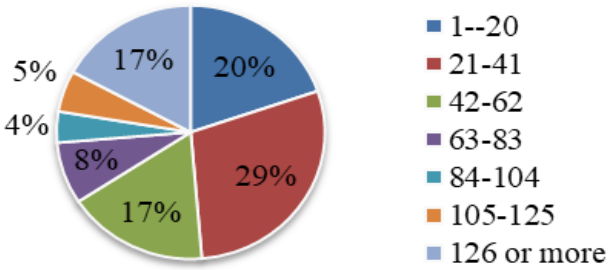
The results related to the participant type of 75 studies (3 studies that present a theoretical background, and 2 game design studies were excluded) examined within the scope of the research are shown in Graph 8.



Graph 8. Participant type in reviewed studies

According to Graph 8, studies determining secondary school students as participants constitute 39% of all studies. Within this scope, 30 studies were conducted (PF5, PF7, DTT6, DTF7, DTF1, DTF4, DTF5, AT9, AT10, AT32, AT35, AT43, AF13, AF16, AF17, AF21, AF28, AF37, AF7, MT11, MT12, MT14, MT15, MT17, MT2, MT3, MT4, MT6, and MT9). Studies in which primary school students participated comprised 19% of all studies. Accordingly, it is seen that primary school students participated in 14 studies (PT1, PF6, DTT3, DTF8, AT18, AT8, AF22, AF34, AF38, AF4, MT1, MT10, MT16, and MT7). Preservice teachers participated in 13 studies (PT3, PT4, DTF2, AT1, AT19, AT25, AT26, AT2, AT29, AT30, AT31, AT44, AF41, and AF42). These studies make up 17% of all studies. Preschool students participated in 4 studies (AF11, AF24, AF23, and MT8). These studies constitute 5% of all studies. There are 3 studies in which teachers took part as participants (AT20, FY28, and FY43), and these studies account for 4% of all studies. There are 3 studies in which secondary school students and mathematics teachers participated together (AF12, AF46, and AF3). These studies constitute 4% of all studies. There are 3 studies including documents (AT45, AT6, and AF39), which correspond to 4% of all studies. Two studies include primary and secondary school students (AF15 and AF36). These studies account for 3% of all studies. Two studies were conducted in which primary school students and primary school teachers took part (AF33 and MT5). These studies make up 3% of all studies. One study was conducted in which parents took part (PT2), while one study was carried out in which high school students (MT13) participated. These studies each constitute 1% of all studies.

The results of 75 studies (3 studies that present a theoretical background, 1 meta-analysis and 1 meta-synthesis studies were excluded) examined within the scope of the research in terms of the number of participants calculated as individuals, as seen in Graph 9.



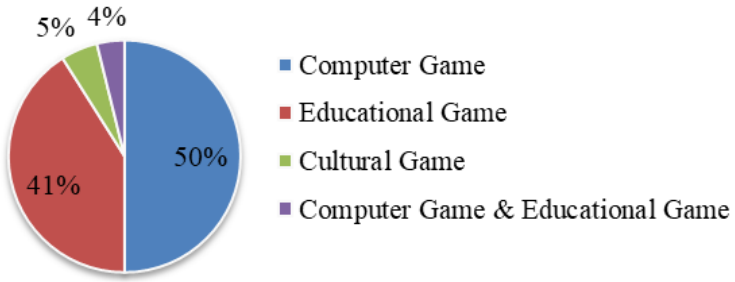
Graph 9. Number of participants in reviewed studies

According to Graph 9, 22 studies included between 21 and 41 participants with a percentage of 29% (PT2, PT3, DTT3, DTF7, AT9, AT10, AT25, AT26, AT32, AT44, AT45, AT6, AT8, AF28, AF39, AF46, MT1, MT11, MT12, MT13, MT14, and MT8). 15 studies included some participants between 1 and 20 (PT4, PF7, AT1, AT19, AT20, AT30, AT31, AF12, AF27, AF4, AF7, MT15, MT17, MT4, and MT9). These studies comprise 20% of all studies. Studies including some participants between 42 and 62 correspond to a percentage of 17%. There are 13 studies within this scope (PT1, MT2, DTF4, DTF5, AT35, AT43, AF11, AF16, AF24, MT10, AF33, AF34, and MT6). It can be seen that there are 14 studies with 126 participants or more, corresponding to a value of 17% (PF5, PF6, DTF8, AT2, AF15, AF22, AF23, AF36, AF37, AF3, AF41, AF42, and MT3). It is

seen that 6 studies included between 63 and 83 participants, and this corresponds to a share of 8% (DTF1, DTF2, DTT6, AF21, AT29, and MT16). Studies involving 105 and 125 participants account for 5% of all studies, corresponding to 4 studies included in this scope (AT18, AF38, AF40, and MT7). 3 studies included some participants between 84 and 104 (AF13, AF17, and MT5). These studies correspond to 4% of all studies.

Distribution of Research by Game Type, Number, and Mathematical Learning Domains to Which the Games Pertain

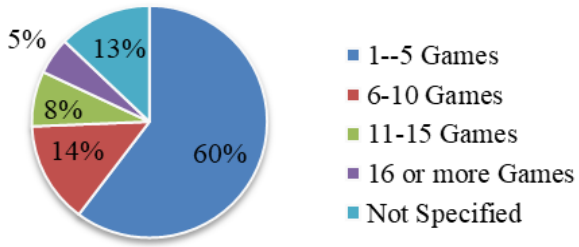
After excluding 1 meta-analysis and 1 meta-synthesis study, the results of the distribution of the remaining 78 studies examined in the search by game type are shown in Graph 10.



Graph 10. Game types of reviewed studies

According to Graph 10, the percentage of studies using computer games constitutes a share of 50% of all studies. Within this scope, it is seen that 39 studies use digital computer games (PT3, PT4, PF5, PF6, PF7 , PF8, AF3, AF4, AF5, AF7, AT10, AF12, AF13, AF15, AF21, AF22, AT25, AF28, AT30, AT31, AF33, AF34, AF36, AF37, AF38, AF39, AF40, AF41, AF42, AF46, MT2, MT9, MT13, DTF1, DTF2, DTF4, DTF5, DTF7, and DTF8). Studies using educational games make up 41% of all studies. In this context, it can be understood that educational games are used in 32 studies (PT1, DTT3, DTT6, AT1, AT9, AT18, AT20, AT2, AT32, AT35, AT43, AT44, AT8, AF11, AF16, AF17, AF23, AF24, AF27, MT1, MT10, MT11, MT12, MT14, MT16, MT17, MT3, MT4, MT5, MT6, MT7, and MT8). It is seen that 4 studies, in which cultural games are used, account for a share of 5% (AF14, AT26, AF47, and MT15). It can be seen that the studies using both computer and educational games correspond to a value of 4%. There are 3 studies that fall within this range (PT2, AT19, and AT29).

The distribution according to the number of games used in the 78 studies examined is as shown in Graph 11.

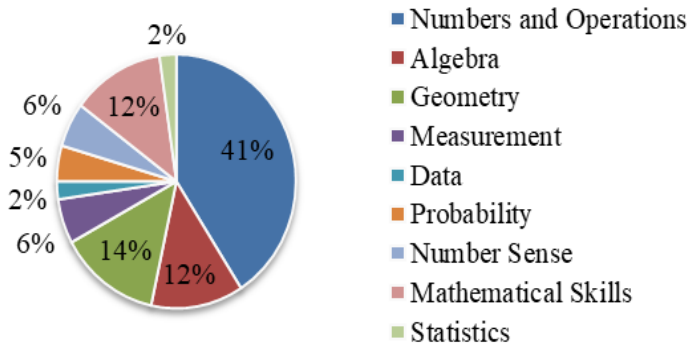


Graph 11. Number of games used in reviewed studies

As shown in Graph 11, the proportion of studies using 1-5 matches is 60% in this study.In this context, it is seen that 47 studies were conducted (PT1, PT4, PF5, PF6, AF3, AF4, AF5, AF7, AT10, AF11, AF13, AF14, AF15, AF16, AF17, AF21, AF22, AT26, AF28, AT30, AT31 , AT32, AF33, AF34, AF36, AF37, AF40, AF41, AT43, AF46, AF47, MT4, MT5, MT6, MT8, MT9, MT13, MT14, PF7, PF8, DTF8, MT17, DTF1, DTF2, DTF4, DTF5, and DTF7). Studies using 6-10 games make up a percentage of 14% of all studies. It is seen that there are 11 studies included in this range (AT18, AF23, AT25, MT1, MT3, MT7, MT10, MT11, MT15, DTT3, and DTT6). Studies in which the number of games used is not specified correspond to a value of 13%. It can be seen that these studies are 10 in number (PT2, PT3, AT1, AF12, AT19, AT20, AF24, AF27, AT29, and AF42). Studies using some games among 11-15 constitute a value of 8%. In this context, it is seen that there are 6 studies (AT8, AT35, AF38, MT2, MT12, and MT16). Studies in which 16 or more games are used constitute

5% of all studies. In this context, it was determined that 4 studies were carried out (AT2, AT9, AF39, and AT44).

It can be seen that the games used in 80 studies examined within the scope of the research address more than one learning area. For this reason, attention was paid to how often the learning domains were the subject of investigation when the chart was created.Accordingly, the distribution of the mathematics learning areas to which the games used in the research are related can be seen in Graph 12.

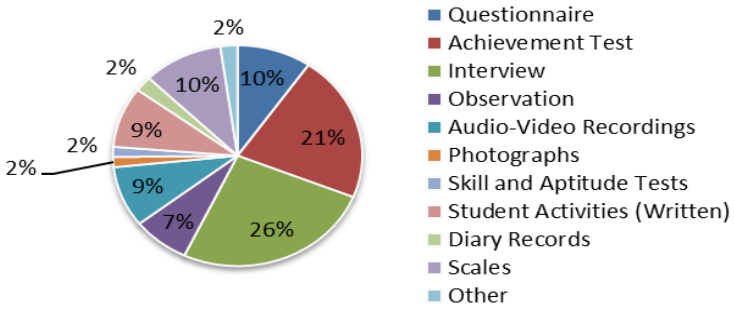


Graph 12. Mathematics learning areas that reviewed studies are related to

According to Graph 12, the "numbers and operations" learning area constitutes 41% of all learning areas. It was determined that 36 studies were conducted in this context (PT1, PF6, PF7, PF8, AF4, AF5, AF7, AT8, AT10, AF11, AF15, AF17, AT18, AF22, AF24, AF27, AT32, AF34, AF36, AF37, AT44, MT1, MT2, MT4, MT6, MT7, MT9, MT10, MT11, MT14, MT15, MT16, DTF2, DTF4, DTT6, and DTF8). Studies dealing with the "geometry" learning area correspond to a value of 14%. In this context, there are 12 studies (AT1, AF4, AT9, AT31, AF34, AT44, MT3, MT5, DTF2, DTT3, DTF4, and DTF8). Studies in the learning area of "algebra" constitute 12% of all studies. In this context, 11 studies were carried out (PF7, AF21, AF28, AT44, AF46, AF47, MT17, DTF2, DTF4, DTF5, DTF7, and DTF8). The "measurement" learning area constitutes 6% of all learning areas. Within this scope, there are 5 studies (PF6, AT8, DTF1, DTF2, and DTF8). Studies prepared for "mathematical skills" constitute 12% of all studies. It is seen that 11 studies were included in this scope (AF12, AF13, AF14, AF16, AT30, AF33, AF38, AF40, AF41, AF42, and AT43). The games used in 5 studies aim at creating "number sense", comprising 6% of all studies (AF11, AF23, AF24, AF27, and MT8). It was determined that the games used in 4 studies were prepared for the "probability" learning area (AF5, AT44, MT12, and DTF4). Studies conducted within this scope account for 5% of all studies. Studies dealing with the "data" learning area correspond to a value of 2%. It was observed that there are 2 studies in this context (AT8 and AT44). Studies carried out in the "statistics" learning area account for 2% of all studies. In this context, it is seen that there are 2 studies (AF5 and DTF4).

Distribution of Data Collection Tools, Data Analysis Types, and Validity and Reliability Methods Used in the Conducted Studies

Since 4 of the 80 studies examined in the research were conducted at the theoretical level, they did not require the use of a data collection tool. In the remaining 76 studies, it is understood that more than one data collection tool was used. Accordingly, the obtained results are as seen in Graph 13.

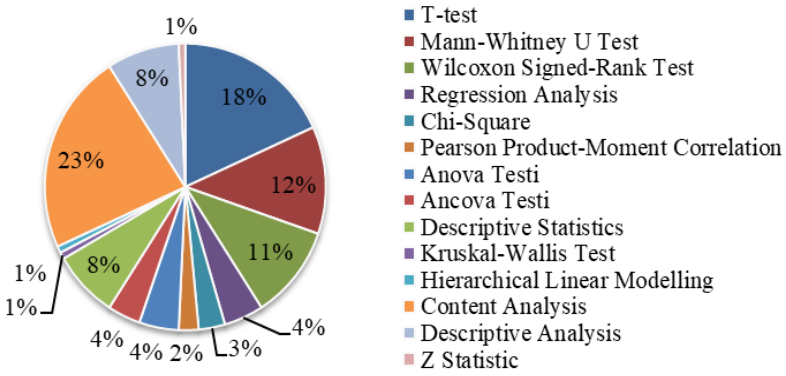


Graph 13. Data collection tools used in reviewed studies

*The information in Graph 13 was created by considering all the data collections used in the studies.

According to Graph 13, studies that collected data through interview constitute 26% of all studies. There are 35 studies included in this scope (PT2, PT3, PT4, AT1, AT2, AF3, AF4, AF12, AF13, AF16, AT18, AT19, AT20, AT25, AT26, AF27, AF28, AT32, AF33, AF34, AF36, AF41), AF46, MT1, MT2, MT4, MT5, MT6, MT7, MT9, MT12, MT14, MT15, MT17, and DTF7). Studies in which achievement tests were used as data collection tools correspond to a value of 21%. In this context, there are 29 studies (PT1, AT8, AT9, AT10, AF11, AF13, AT18, AF21, AF22, AF28, AF34, AT35, AF38, AF40, AF41, AT43, MT1, MT2, MT6, MT7, MT10, MT11, MT12, MT13, MT14, MT16, DTT6, DTF7, and DTF5). Data were collected through scales in 14 studies, with a value of 10% (AT18, AF23, AF37, AT43, MT5, MT6, MT7, MT8, MT10, MT11, MT13, MT17, DTF2, and DTT6). Questionnaires were utilised in 13 studies (PF7, PF8, AF3, AF13, AF17, AF22, AF28, AF36, AF40, AF42, DTF1, DTF4, and DTF8). These studies correspond to 10% of all studies. Studies utilising audio-video recordings as data collection tools comprise 9% of all studies. In this context, 12 studies were identified (AF4, AF7, AF16, AT18, AF28, AT30, AT31, AF34, MT1, MT4, MT7, and MT15). The 10 studies utilising observations correspond to 7% of all studies (AT2, AF4, AT18, AF27, AF33, AF46, MT1, MT2, MT7, and MT15). Various criteria and forms for document analysis were used as data collection tools in the 3 studies included under the "other" heading (MT5, AT29, and AF33). These studies make up 2% of all studies. Studies in which skill and aptitude tests were used as data collection tools correspond to a value of 2%. Within this scope, 2 studies were conducted (MT3 and DTT3). Diaries were used as data collection tools in 2% of the studies. There are 3 studies in this context (AF15, AF28, and MT12). Studies in which photographs were used as data collection tools account for 2% of all studies. In this context, there are 2 studies (AF16 and AF28). 12 studies use data collection tools based on student activities (grades, game scores, question solutions, etc.) (PF5, PF6, AF7, AF15, AF24, AT25, AF28, AF37, AF41, MT4, MT15, and DTF5). These studies correspond to 9% of all studies. One study in which a document prepared as a guide was used as the data collection tool corresponds to 1% of all studies (AT44). In 2 studies, no information is given about how the data were collected, constituting 1% of all studies (AT6 and AT45).

It was observed that more than one analysis test was used to analyse the data of the 80 studies examined within the scope of the research. For this reason, examination was made on how many times the analyses were used in the studies. Accordingly, the results obtained are as seen in Graph 14.

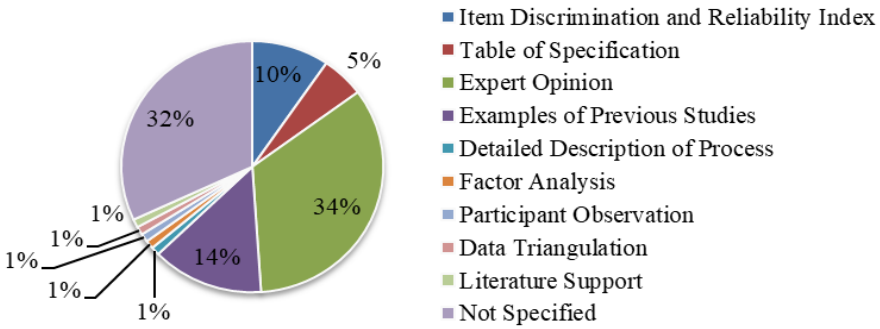


Graph 14. Data analyses used in reviewed studies
*The information in Graph 14 was created by considering all the analysis methods used in the studies.

According to Graph 14, studies conducted with content analysis constitute 23% of all studies. It can be seen that there are 30 studies in this context (PT2, PT3, PT4, AT1, AT2, AF4, AF7, AF12, AF16, AT19, AT20, AT25, AT26, AF27, AF28, AT29, AT32, AF33, AF34, AF36, AF39, AT45, MT1, MT2, MT4, MT15, MT17, DTT3, DTT6, and DTF7). Studies in which t-test analysis was performed constitute 18% of all studies. Within this scope, there are 24 studies (PT1, AT8, AF11, AF13, AT18, AF34, AF36, AF37, AF38, AF40, AF41, AT43, MT1, MT2, MT3, MT7, MT10, MT12, MT14, MT16, MT17, DTF1, DTF4, DTF5, and DTT6). Studies using Wilcoxon signed-rank test analysis correspond to a 11% value. In this context, it is observed that there are 14 studies (AT9, AT10, AF15, AT35, AT43, MT5, MT6, MT8, MT11, MT13, MT17, DTF2, DTT3, and DTT6). Studies using descriptive statistics comprise 8% of all studies. It is seen that 10 studies were carried out in this context (AT18, AF21, AF24, AT32, AF41, AF42, MT13, MT14, DTF5, and DTF8). Studies using descriptive analysis also correspond to 8% of all studies. There are 11 studies included in this scope (PF5, AF28, AT30, AT31, AT44, AF46, MT4, MT5, MT6, MT9, and MT14). Studies in which Anova test analysis was performed account for 4% of all studies. In this context, it is seen that there are 6 studies (AF11, AF22, AF23, AF36, AF37, MT1, and DTF8). Studies in which Mann-Whitney U test analysis was performed comprise 12% of all studies, and these are 16 in number (AT9, AT10, AF15, AT35, AT43, MT2, MT5, MT6, MT8, MT10, MT11,

MT12, MT13, MT16, DTF2, and DTT3). The 6 studies in which regression analysis was performed make up 4% of all studies (PF5, PF6, AF4, AF34, AF40, and DTF5). Studies in which the Ancova test was used correspond to a value of 4%. Within this scope, it can be seen that there are 5 studies (PT1, AF21, AF24, DTT6, and DTF7). Studies using Pearson product-moment correlation analysis correspond to a value of 2%. There are 3 studies evaluated in this context (AF22, AF24, and AF41). Studies using chi-square analysis correspond to 3% of all studies. In this context, 4 studies were conducted (AF5, AF17, AF34, and AF42). There is one study using hierarchical linear modelling (DTF1), one in which the Kruskal-Wallis test was performed (AF15), and one in which Z statistical analysis was performed (DTF5). These studies each constitute 1% of all studies.

Four of the 80 studies examined within the scope of the research were excluded from the scope of the analysis because they were of the type (theoretical) for which a validity study could not be carried out. Accordingly, the results regarding the validation methods used in the 76 studies examined are as shown in Graph 15.

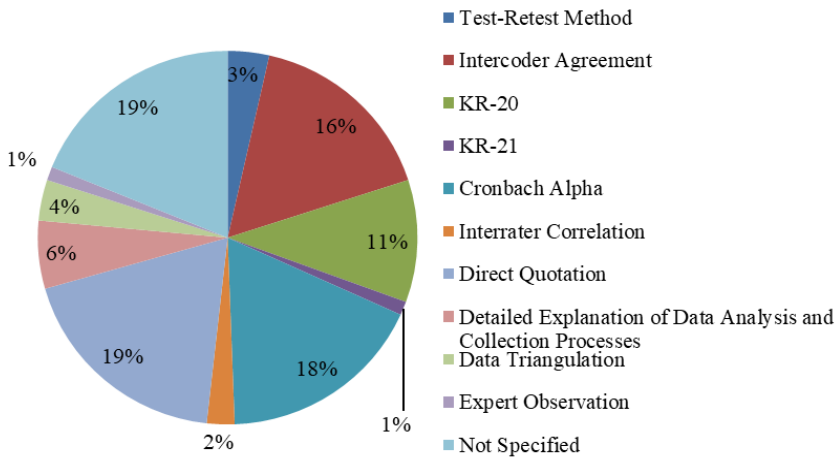


Graph 15. Validation methods of reviewed studies

*The information in Graph 15 was created by considering all the validation methods used in the studies.

According to Graph 15, studies in which expert opinion was sought as a validation method constitute 34% of all studies. In this context, there are 32 studies (PT1, PT2, PT3, PT4, PF7, AT1, AT8, AT9, AT10, AT18, AT19, AT20, AF21, AT25, AT26, AT29, AT30, AT31, AT32, AT35, AF39, AT45, MT5, MT6, MT7, MT9, MT10, MT11, MT14, MT15, MT16, and DTF8). Studies for which a validation method is not specified correspond to a value of 32%. There are 30 studies for which no validation method is specified (PF5, PF6, AT2, AF3, AF4, AF7, AF11, AF12, AF13, AF15, AF17, AF22, AF23, AF24, AF27, AF28, AF33, AF37, AF38, AF40, AF42, AT43, AT44, AF46, AF47, MT2, MT3, DTF1, DTF2, and DTF4). Studies that show examples of previous studies in the literature as a validation method constitute 14% of all studies. 13 studies were conducted (PT2, AF16, AT18, AT20, AF34, AF36, AF41, MT4, MT8, MT12, MT13, DTF5, and DTF8). Studies in which item discrimination and difficulty index analysis was used correspond to a value of 10%. In this context, there are 9 studies (AT8, AT9, MT2, MT6, MT10, MT14, MT16, DTT3, and DTT6). Studies in which a table of specifications was used as the validation method comprise 5% of all studies. It is seen that there are 5 studies included in this scope (PT1, AT8, AT9, MT6, and DTT3). A detailed process description ensured validity in one study in which a qualitative method was used. This study constitutes a value of 1% (DTT6). One study used factor analysis as the validation method corresponds to 1% of all studies (MT11). One study was conducted in which validity was ensured by participant observation (MT17), and this study represents a value of 1% of all studies. There is only one study in which validity was ensured by data triangulation, and this study also constitutes 1% of all studies (DTF7). There is 1 study where validity was ensured based on the literature (MT1), which corresponds to a value of 1% of all studies.

Four of the 80 studies examined in the study were not included in the analysis because they were of the type (theoretical) for which a reliability study could not be performed.Accordingly, the results regarding the methods used to ensure reliability in the 76 studies examined are as seen in Graph 16.



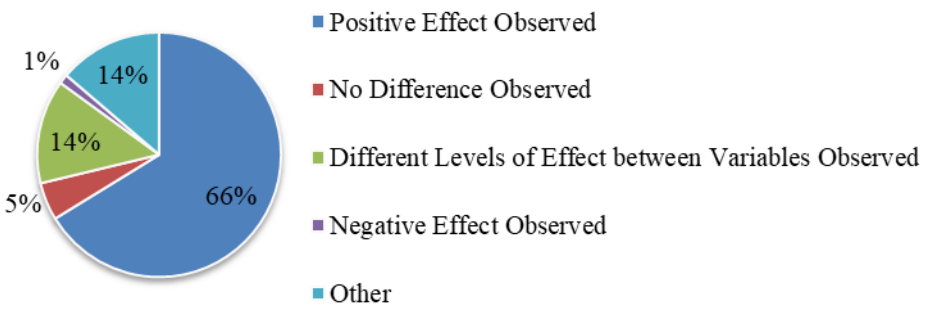
Graph 16. Methods of ensuring reliability in reviewed studies

*The information in Graph 16 was created by considering all the reliability methods used in the studies.

According to Graph 16, the studies examining the Cronbach alpha coefficient as the method of determining reliability constitute 18% of all studies. In this context, it was seen that 15 studies were carried out (AT10, AT35, AF13, AF15, AF23, AF24, AF38, PT1, MT5, MT6, MT11, MT16, MT17, DTF5, and DTT6). The percentage of studies that do not specify a reliability determination method is 19%. In this context, it can be seen that 16 studies do not provide information about the reliability determination method (PF5, PT3, AF3, AF4, AF16, AF17, AF21, AF28, AF42, AT43, AF46, AF47, MT3, MT7, DTF2, and DTF7). Studies in which intercoder agreement was used as the reliability method correspond to a value of 16%. There are 14 studies within this scope (PT4, PF7, AT1, AT2, AF7, AF22, AT25, AT29, AF34, AT44, DTT6, MT9, MT12, and MT14). Studies in which direct quotations were preferred as the method of reliability constitute 19% of all studies. In this context, there are 16 studies (PT2, AT1, AT2, AF7, AF12, AT18, AT19, AT20, AT26, AF27, AT31, AT32, MT1, MT4, MT9, and DTT3). Studies in which KR-20 was used as the reliability method cover 11% of all studies. KR-20 calculations were made in 9 studies (AT8, AT9, MT2, MT8, MT10, MT13, MT14, DTT3, and DTT6). The percentage of studies in which KR-21 was used as the reliability method corresponds to a value of 1%. In this context, there is 1 study (MT13). A detailed explanation method for the data analysis and collection process was used in 5 studies (AF27, AT30, AT31, AF41, and MT15) and these studies correspond to a value of 6%. Data triangulation was used in 3 studies (AT20, AF33, and MT4), comprising 4% of all studies. Studies in which reliability was calculated using the test-retest method correspond to a value of 4%, and in this context, there are 3 studies (AF23, DTF1, and MT8). There are 2 studies in which the correlation value inter-coder consistency was calculated (AF39 and MT17), and these studies account for 2% of all studies. Studies in which an attempt was made to ensure reliability by consulting expert opinion constitute 1% of the studies, and there is 1 study evaluated in this context (AT45).

Distribution of the Conducted Studies According to their Results

The distribution of the results of the 80 studies that were examined as part of the study is shown in Graph 17.



Graph 17. Results of reviewed studies

According to Graph 17, 66% of the conducted studies resulted in a positive effect. There are 53 studies included in this scope (PT1, PT2, PT4, PF7, PF8, AT1, AT6, AF7, AT8, AT9, AT10, AF11, AF13, AF15, AF16, AT18,

AT19, AT20, AF21, AF23, AF24, AT25 , AT26, AF27, AF28, AT29, AT30, AT31, AT32, AF33, AF34, AT35, AF38, AF41, AF42, AT45, AF46, DTF1, DTT3, DTF5, DTT6, MT1, MT5, MT6, MT7, MT8, MT9 , MT11, MT12, MT14, MT15, MT16, and MT17). Studies in which different levels of effect were observed between the variables correspond to a value of 14%. In this context, there are 11 studies (AF22, AF37, AT43, DTF2, DTF4, DTF7, MT2, MT3, MT4, MT10, and MT13). Studies in which different effects were not observed correspond to a value of 5%. It is seen that there are 4 studies in this scope (AF4, AF12, AF40, and DTF8). Studies evaluated within the scope of "other" studies comprise 14% of all studies. There are 11 studies in this context (PF5, PF6, AT2, AF3, AF5, AF14, AF17, AF36, AF39, AT44, and AF47). There is only one study in which a negative effect was observed (PT3), and this study corresponds to a value of 1%.

Discussion and Conclusion

This section discusses the results obtained from the study in line with the research problems. When we examine the distribution of the studies on the use of games in mathematics education according to their type, which is explained in the first sub-problem of the research, it can be said that studies of the article type gain prominence. When the distribution by years is examined, it can be seen that there is a general increase, including 2019, while the number of studies conducted in the following years shows a tendency to decrease. Especially in 2019, the maximum number of studies was reached by researchers in article, thesis and conference paper studies (Cohrssen & Niklas, 2019; Ergül & Doğan, 2019; Galarza, 2019; Liang et al., 2019; Machaba, 2019; White & McCoy, 2019; Yılmaz, 2019). If active learning brought about by a constructivist approach in mathematics teaching is desired, then games are among the most important methods to be used in this regard (Erkin-Kavasoğlu, 2010). Indeed, in recent years, studies on games in mathematics education have started to increase (Türker & Arslan, 2021). In this context, the emerging result meets the researchers' expectations. On the other hand, the reason for the decrease in the number of publications after 2019 is thought to be related to the COVID-19 pandemic process. Considering that half of the games in the studies examined are computer games, the use of technology comes to the fore. During the period COVID -19, the most important problem for teachers is the lack of technological pedagogical knowledge (Türker & Duendar, 2020). This situation can be cited as the reason for the decrease in studies on the use of games in mathematics education. In this context, the number of technolo gy courses offered at the undergraduate level could be increased.

When the results for the second sub-problem of the research are examined, it can be seen that nearly half of the articles were scanned in indexes such as Scopus and TR indexed, while 17% of them appear in SSCI-indexed journals. When the postgraduate theses are examined, it can be seen that the great majority of studies on teaching mathematics with games are studies conducted in Turkey (Başkahya, 2021; Dönmez, 2017; Ergül, 2021; Galiç, 2020; Koç-Deniz, 2019; Sönmez, 2018). The reason for this is thought to be the 2018 curriculum announced by the Higher Education Council (YOK). In fact, together with this curriculum, the course for teaching mathematics with games was included in the programme, and after this date, studies carried out on this subject gained momentum. Participation in international conferences was mainly observed in studies conducted in the form of papers.

The results obtained for the third sub-problem of the research show that the conducted studies are mainly aimed at determining the effect of teaching mathematics with games on mathematical achievement (Kokandy, 2021; Lee & Choi, 2020; McIntosh, 2018; Stanton, 2017; Tärning & Silvervarg, 2019; Watson-Huggins, 2018). This is followed by studies in which opinions about the use of games in teaching mathematics are discussed (Bragg, 2007; Deng, Wu, Chen & Peng, 2020; Doğan & Sönmez, 2019; Machaba, 2019). In parallel with these results, when the studies are examined, it is seen that mostly experimental design studies are included in quantitative research studies (Lee & Choi, 2020; Nfon, 2018; Stanton, 2017; Yılmaz, 2019). These studies are followed by case studies included in qualitative research studies (Barreto, Vasconcelos & Orey, 2017; Marange & Adendorff, 2021; White & McCoy, 2019). In the study by Divjak and Tomic (2011) in which computer games used in mathematics education between1995-2010 were examined, it was determined that the majority of the conducted studies were carried out in accordance with the nature of quantitative research. The reason could be the study of the effects of teaching mathematics with games on different variables in the study.

The results obtained for the fifth sub-problem of the research reveal that about one-third of the sample numbers in the studies are in the range of 21-41 (Boz, 2018; Galarza, 2019; Tükle, 2020). Moreover, when the sample groups in the studies are examined, it is seen that mostly secondary school students were studied (Atasay, 2018; Divjak & Tomić, 2011; Graceota, & Slamet, 2021; Koç-Deniz, 2019), while primary school students follow this group (Ergül, 2021; Ergül & Doğan, 2019; Kokandy, 2021). In the study conducted by Türker and Arslan (2021), in which the studies on teaching mathematics with games between 2002-2017 were examined, it was determined that the sample groups consisted of primary and secondary school students. However, another

noteworthy point is that only a small number of studies was conducted with student groups at the preschool level (Liang et al., 2019; Skillen, Berner & Seitz-Stein, 2018). Yet the game is a concept that is appropriate, especially for children of preschool age, and is an important tool in the development of the child, that benefits his/her mental, psychological, biological, and sociocultural development (Gür & Kobak-Demir, 2016). In this context, it can be seen that studies on educational mathematics games belonging to the preschool period, when basic mathematical knowledge and skills are developed, should be included. Using games in mathematics may be mainly tried as a teaching method for different age groups.

When the studies conducted between 2017-2021 are examined, it is seen that 49% of the studies include computer games (Kalish, 2017; Kiili, Ojansu, Lindstendt & Ninaus, 2018; Rondina & Roble, 2019), while 42% of them include educational games (Başün & Doğan, 2020; Demirkaya, 2017; Nfon, 2018). While 61% of the studies include between 1 and 5 games (Es-Sajjade & Paas, 2020; Koneva & Shabanova, 2021), a significant percentage of the content of the games belongs to the "numbers and operations" learning area (Eyster, 2017; Galarza, 2019; Wouters & Van Der Meulen, 2020). In the research conducted by Joung and Byun (2020), in which digital mathematics games were analysed according to National Council of Teachers of Mathematics [NCTM] standards, it was determined that the majority of the games were related to the "numbers and operations" learning area. However, very few games were prepared for the "data", "statistics" and "probability" learning areas. At this point, it may be thought that more studies should be included in these learning areas that are especially important in terms of mathematical literacy, which has come to the fore recently.

It is seen that interviews were used as the data collection tool in 35 of the 80 studies examined, while achievement tests were used in 29 studies. In parallel with these results, for data analysis, most of the studies included content analysis and t-test data, which is one of the parametric tests. Furthermore, expert opinion and calculation of the Cronbach alpha coefficient were the most preferred methods used to ensure validity and reliability, respectively. In addition, it can be seen that many studies do not specify which methods were used (Koneva & Shabanova, 2021; Marange & Adendorff, 2021). Yet it is stated in studies that the quality of a study is directly proportional to good determination of validity and reliability in the study (Golafshani, 2003; Punch, 2005). It follows that methods to ensure validity and reliability in qualitative and quantitative research should be considered in future studies of mathematics education, both in this and other areas. Moreover, this situation will also facilitate the evaluation of studies.

Regarding the last sub-problem of the research, the results obtained from the studies show that in 65% of the studies, mathematics teaching with games had a positive effect. Research has shown that teaching with games increases students' academic achievement (Divjak & Tomić, 2011; Karamert, 2019; Pehlivan, 2020; Türkmen, 2017) and positively affects their attitudes toward mathematics (Tükle, 2020), and that research participants have a positive attitude toward the use of games in mathematics courses (Koç-Deniz, 2019; Russo et al., 2021; Watson-Huggins, 2018).These results are in line with previous research studies conducted on this subject (Divjak & Tomic, 2011; Turgut & Temur, 2017; Türker & Arslan, 2021). However, in studies where negative effects were observed, it was found that teachers were not aware of the use of games in mathematics teaching (Pilten, Pilten, Divrik & Divrik, 2017) and that there was a lack of harmony between technological games and pedagogical principles (Lindström, Gulz, Haake & Sjödén, 2011).In addition, results are also included on teachers' need for game materials (Kondratieva & Freiman, 2011), the low use of games in some countries (Nabie, 2008), some needs for integrating game use into the curriculum (Akintunde et al., 2020; Callaghan, Long, van Es, Reich, & Rutherford, 2017; Fouze & Amit, 2018; Graceota & Slamet., 2021; Koneva & Shabanova, 2021; Shabrina et al., 2020), the effects of designing game components and the effects of game design (Ke, 2014; Rawansyah et al., 2021; Trujillo, Chamberlin, Wiburg & Armstrong, 2016), and the inappropriateness of using games according to certain standards (NCTM) (Joung & Byun, 2020). To eliminate some negative situations, it is recommended that the Ministry of National Education act as a problem solver, e.g. through technical, material and academic support, teacher training, etc.x

Author (s) Contribution Rate

The authors contributed equally to the study.

Conflicts of Interest

The authors declare no conflict of interest.

Ethical Approval

This study not need ethical approval in terms of the subject.

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The Relationship Between 21st Century Learner Skills and Program Literacy Levels of Pre-Service Teachers

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The Relationship Between 21st Century Learner Skills and Program Literacy Levels of Pre-Service Teachers

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Abstract

The aims to examine the relationship between preservice teachers' 21st-century learner skills and their curriculum literacy levels. 476 preservice teachers studying at the Faculty of Education of a state university in Turkey participated in the study. The relational survey model was adopted in the study. The data were collected through "21stCentury Learners Skills Use Scale" and "The Curriculum Literacy Scale". Pearson Product Moments Correlation Coefficient and regression analysis were performed. The results showed that the participants' 21st century learner skills and curriculum literacy were at a high level and their 21st century learner skills and curriculum literacy levels did not differ significantly by gender. It was found that the participant's 21st century learner skills did not significantly differ by the department. However, it was discovered that the curricular literacy levels varied greatly by department. The participants in the preschool education department were found to have higher levels of curriculum literacy levels. In addition, a significant, moderate, and positive relationship was found between the participants' 21st century learner skills and curriculum literacy. Finally, 21st-century learner skills were statistically significant predictors of program literacy levels.

Keywords: 21st-century learner skills, Curriculum literacy, Preservice teachers

Introduction

Today, the new generations of students, many of whom are university-educated, are trying to live in a world that develops rapidly and in a flawed way, and they need to be prepared to develop the skills of the new century to adapt to such a developing world (Purpose, 2021). The importance of 21st century skills, which contribute to the development of individuals living in society in accordance with the conditions of their age and their desire to constantly improve themselves, has increased with the ever accelerating and emerging technology. With this rapid change and development, individuals' skills and abilities in any sector also change rapidly (Göksün, 2016). With this change, in addition to the transmission of information, life skills are developing, which are necessary to inform students during the educational process, to teach them moral values correctly and effectively, and to facilitate the adaptation of individuals to society.

The 21st-century skills, which students and individuals need to have to adapt to the 21st century, are defined by Ministry of National Education of Turkey (MEB), P21 and OECD (Cansoy, 2018). From past to the present, it has been thought that reading, writing, and mathematics formed the basis of learning in the education process. However, according to the US Education Minister Arne Duncan (2009), with the 21st-century skills, which have been introduced with the changing technology, problem-solving, productivity, creativity, and perseverance should also be included in the education of learners (Larson & Miller, 2011). Trilling and Fadel (2009) define 21st century skills as the skills individuals need to succeed. While it is necessary for a learner or teacher to develop cognitive skills such as mathematics and literacy to be successful in the twenty-first century, it is also necessary to think logically, produce practical solutions to any problem, and master non-cognitive skills such as responsibility and leadership (Kivunja, 2014; Pellegrino & Hilton, 2012). Learners who adapt to 21st-century skills will be able to communicate effectively at the end of this process. By participating in group work, they can both take a leadership role and develop a sense of responsibility. The competencies that learners should possess in the 21st century can be briefly summarized as follows (Yalçın, 2018):

- Innovation skills
- Digital literacy

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- Productivity
- Media and information communication technologies

Life and career skills, which are 21st-century abilities that include information and communication technologies utilized for self-learning by both teachers and learners, help in the development of skills such as leadership, ethical behaviors, personal accountability, and social responsibility. (Kaufman, 2013). For learners to master 21st-century skills, teachers are also required to conduct effective teaching. Individuals willing to teach 21st-century skills, in other words, teachers, should have the flexibility to teach these skills (Clark, 2009). Learners interact the most with teachers after friends and family. To teach 21st century skills, the teacher and the learner should be communicated well and effectively, and the teachers should guide the learners (Palfrey & Gasser, 2008; Göksün & Kurt, 2017). Furthermore, it is very important for teachers to define and be aware of learners' personal characteristics and development, what they know and do not know, and their interests in this process (Callison & Lamb, 2004). Additionally, the following three elements need to progress and be applied harmoniously for 21st-century skills to be effective:

- To meet and renew the needs of the regions where the schools are located and schools
- A new assessment to make rich learning effective and measure it correctly.
- Educators must ensure that educational programs are completed (Roterham & Willingham, 2009).

It is of crucial importance and required for learners and teachers to integrate with the curriculum to be prepared and adapt to the skills of the 21st century, the first decade of which has ended. Therefore, to teach 21st century skills effectively and efficiently, educational programs have been developed to prepare learners for the 21st century (Toptal, 2021; Larson & Miller, 2011). Educational programs are officially approved documents used to transfer values and achievements that are considered important and valuable by the society to children in an effective and accurate way. The educational programs ensure that the education process of a country is planned and programmed. Therefore, educational programs elucidate and guide the education and future of a country. In sum, the educational program can be regarded as the map of the education process (Bolat, 2017; Erdem & Eğmir, 2018).

The curriculum is divided into target, content, learning and teaching, and assessment and evaluation. Curriculum literacy needs all four elements of the curriculum to develop. If these four elements are adapted, the proficiency of curriculum literacy will also be improved (Çetinkaya & Tabak, 2019). Curriculum literacy or program literacy was also mentioned in the content knowledge proficiency section of the teaching profession issued by MEB in 2017. If the instructors have higher levels of curriculum literacy proficiency, the students or preservice teachers will be more likely to develop curriculum literacy proficiency (Akyıldız, 2020). In addition, curriculum literacy, one of the features teachers and preservice teachers should possess, appears to contribute to the individual's development and the shaping of the expected behaviors (Karagülle et al., 2019). This study investigated 21st-century skills and program literacy levels of preservice teachers. The 21st-century skills and program literacy levels of preservice teachers and their effects on each other were determined. Thus, this study will contribute to the literature by revealing the relationship between 21st-century skills and program literacy levels.

Method

The relational survey model, one of the quantitative research methods, was used in this study to examine the relationship between 21st-century learning skills and curriculum literacy levels of preservice teachers. In the relational survey model, data are collected, and the relationship between the collected data is investigated (Can, 2018). In line with the research model, there were two variables in this study: 21st-century skills as the independent variable and curriculum literacy as the dependent variable.

Participants

The universe of this study consisted of preservice teachers studying in the 3rd and 4th grades at the Faculty of Education of a Turkish state university in the 2020-2021 academic year. Convenience sampling was used to select the sample, a type of sampling that includes the most time and economically appropriate individuals in accordance with the purpose of the study. (Balcı, 2020). All the students were tried to be reached, and the participation wasvoluntarily. As a result, 476 students participated in the study. The demographic information of the participants is presented in Table 1.

Table 1. Demographic information of the participants

Variable		Frequency (n)	Percentage (%)
Gender	Female	367	77,1
	Male	109	22,9
	Total	476	100
Department	Preschool Education	127	26,7
	Elementary Mathematics Education	28	5,9
	Social Sciences Education	107	22,5
	Classroom Instruction Education	31	6,5
	English Language Education	29	6,1
	Elementary Science Education.	40	8,4
	Psychological Counselling and Guidance Education	114	23,9
	Total	476	100

Of the participants, 367 (77,1%) were female, and 109 (22,9) were male. The departments of the participants were as follows: 127 (26,7) pre-school education, 28 (5,9%) elementary mathematics education, 107 (22,5%) social sciences education, 31 (6,5%) classroom instruction education, 29 (6,1%) English language education, 40 (8,4%) elementary science education, and 114 (23,9%) psychological counseling and guidance education.

Data Collection Tools

21st Century Learners Skills Use Scale

21st Century Learners Skills Use Scale was developed by Orhan-Göksün (2016) and consisted of 31 items scored on a five-point Likert type scale. The scale has 4 sub-scales: cognitive skills, autonomous skills, collaboration and flexibility skills, and innovativeness skills. There is no reverse-coded item on the scale. The Cronbach's Alpha value was found to be 0.877, 0.706, 0.672, and 0.818 for the sub-scales, respectively, and 0.892 for the total scale (Orhan Göksün, 2016). This study calculated it as 0.894, 0.715, 0.721 and 0.897 for the sub-scales, respectively, and 0.864 for the total scale. These values indicated that the study was reliable. The distribution of scale items to dimensions is as follows: Cognitive Skills (Items 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 21, 22, 23, 25, 28, 29), Autonomous Skills (Items 3, 17, 18, 26, 30, 31), Collaboration and Flexibility Skills (Items 13, 14, 15, 16, 24, 27), Innovativeness Skills (Items 19, 20)

Curriculum Literacy Scale

The Curriculum Literacy Scale, developed by Bolat (2017), consisted of 31 items scored on a five-point Likert type scale and two sub-scales, namely reading and writing. There is no reverse-coded item on the scale. The Cronbach's Alpha value was found to be 0.888 for the reading, 0.907 for the writing, and 0.94 for the total scale (Bolat,2017). This study calculated it as 0.93 and 0.94 for the sub-scales and 0.96 for the total scale. These values showed that the study was reliable.

Data Analysis

In the study, 'the means and standard deviations of the scales were calculated to examine the participants' 21st century learner skills and curriculum literacy levels. The values were interpreted as follows: "1-1.79" very low, "1.80-2.59" low, "2.60-3.39" moderate, "3.40-4.19" high and "4.20-5.00" values as very high. Before data analysis, the data were tested for normality. Skewness and kurtosis values of the data are shown in Table 2.

Table 2. The skewness and kurtosis values

Variables			Skewness		Kurtosis	
	$\bar{X}$	sd	Value	Std. Er.	Value	Std. Er.
21st Century Learner Skills Use	4,09	.540	-.013	.112	.699	.223
Cognitive	4,28	.532	-.065	.112	.254	.223
Autonomous	3,57	.701	-.136	.112	.299	.223
Collaboration and flexibility	3,42	.829	-.182	.112	-.111	.223
Innovativeness	3,87	.841	-.426	.112	-.482	.223
Curriculum Literacy	3,81	.569	.005	.112	-.356	.223
Reading	3,91	.650	.008	.112	-.222	.223
Writing	3,71	.558	-.169	.112	-.198	.223

As shown in Table 2, the values for skewness ranged from -.426 to .008, and the values for kurtosis ranged from -.482 to .699.The fact that the skewness and kurtosis values are between -1 and +1 indicates that the data is normally distributed (Büyüköztürk, 2016). Accordingly, the data in the present study were normally distributed. Since the data showed a normal distribution, in this study, Independent Samples t-Test was performed for the gender and ANOVA for the department. In addition, to determine the source of the difference, Scheffe's test was used as a post-hoc. Furthermore, correlation analysis was used to examine the relationship between 21st-century learner skills and curriculum literacy levels. Pearson correlation coefficients are considered as '0.00-0.29' as low correlation, 'between 0.30-0.69' as moderate correlation, and between '0.70-1.00' as high correlation (Büyüköztürk, 2016). Finally, regression analysis was run to investigate the predictability of 21st-century learner skills on curriculum literacy, which was determined as the outcome variable.

Findings

The descriptive statistics of the 21st-century learner skills and curriculum literacy levels of the participants are presented in Table 3.

Table 3. 21st century learner skills and curriculum literacy levels of the participants

	N	$\bar{X}$	sd	Level
21st Century Learner Skills Use	476	4,09	.540	High
Cognitive	476	4,28	.532	Very High
Autonomous	476	3,57	.701	High
Collaboration and flexibility	476	3,42	.829	Moderate
Innovativeness	476	3,87	.841	High
Curriculum Literacy	476	3.81	.569	High
Reading	476	3.91	.558	High
Writing	476	3.71	.650	High

Table 3 shows that the participants' 21st century learner skills ($\bar{X}$=4,09) and Curriculum literacy ($\bar{X}$=3,81) were high. It was also found for the sub-scales of 21st Century Learner Skills Use Scale that the level was very high in Cognitive Skills ($\bar{X}$=4,28), and high in Autonomous skills ($\bar{X}$=3,57), Collaboration and Flexibility Skills ($\bar{X}$=3,42), and Innovativeness Skills ($\bar{X}$=3,87). The Reading ($\bar{X}$=3,91) and Writing ($\bar{X}$=3,71) sub-scales of the Curriculum Literacy Scale were found to be high.

Table 4 shows the results of the independent samples t-test conducted to determine whether the participants' 21st-century learner skills and curriculum literacy levels differ concerning gender.

Table 4. Independent samples t-test results

	Gender	N	X	S	t	p
A. 21st Century Learner Skills Use	Female	367	4,09	.55	.327	.744
	Male	109	4,27	.50		
A1. Cognitive	Female	367	4,28	.53	.172	.863
	Male	109	4,27	.52		
A2. Autonomous	Female	367	3,52	.70	-2.548	.011
	Male	109	3,72	.67		
A3. Collaboration and flexibility	Female	367	3,42	.83	.009	.993
	Male	109	3,42	.84		
A4. Innovativeness	Female	367	3,85	.86	-.978	329
	Male	109	3,94	.79		
B. Curriculum Literacy	Female	367	3,81	.68	-.379	.705
	Male	106	3,83	.65		
B1. Reading	Female	367	3,91	.56	.097	.922
	Male	109	3,90	.59		
B2. Writing	Female	367	3,70	.64	-.777	.437
	Male	109	3,75	.69		

*p<.05

No significant difference was found in the 21st Century Learner Skills Use Scale and its sub-scales concerning gender. However, in the autonomous skills sub-scale (t=- 2,548, p<.05), a significant difference was revealed in favor of male participants. Finally, a significant difference was not found in the Curriculum Literacy Scale and its sub-scales concerning gender.

Table 5 shows the results of ANOVA, which was performed to investigate whether the 21st-century learner skills and curriculum literacy levels of preservice teachers differ concerning the department they study.

Table 5. The comparison of the participants with regard to department

Scale	Department	N	$\bar{X}$	S	F	p	Difference
A. 21st Century Learners Skills Use	a.Pre-school Edu.	127	4,10	,58	1,437	,199	
	b.Elementay Math Edu.	28	3,96	,43			
	c.Social Sciences	107	4,19	,56			
	d.Classroom Edu.	31	4,13	,67			
	e.English Lang. Edu.	29	4,07	,53			
	f.Elementary Science Edu.	40	4,03	,28			
	g. Psy. Coun. and Guidance	114	4,02	,53			
B. Curriculum Literacy	a.Pre-school Edu.	127	3,94	,69	4,076	,001	a>g g<c
	b.Elementay Math Edu.	28	3,89	,65			
	c.Social Sciences	107	4,02	,64			
	d.Classroom Edu.	31	3,97	,71			
	e.English Lang. Edu.	29	3,76	,69			
	f.Elementary Science Edu.	40	3,75	,59			
	g. Psy. Coun. and Guidance	114	3,63	,60			

*p<.05

As shown in Table 5, the pre-service teachers' 21st Century Learner Skills Use scores did not differ significantly by the department. However, there was a significant difference (F=4,076; p=0.001<0.05) between the Curriculum Literacy Scale and the department of the participants. To reveal the source of the difference, the Scheffe test was used. It was found that the curriculum literacy levels of the preservice preschool teachers were higher than the preservice social sciences studies teachers, who were at a higher level than the preservice Psychological Counselling and Guidance teachers. Table 6 presents the findings of Pearson's Product-Moment Correlation Analysis which was used to determine the relationship between preservice teachers' 21st-century learner skills and their curriculum literacy levels.

Table 6. The relationship between 21st-century learners' skills use and curriculum literacy

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. 21st Century Learners Skills Use	1							
2. Cognitive Skills	,718**	1						
3. Autonomous Skills	,521**	,320**	1					
4. Collaboration and Flexibility Skills	,425**	,330**	,241**	1				
5. Innovativeness Skills	,518**	,428**	,288**	,386**	1			
6. Curriculum Literacy	,517**	,505 **	,394**	,439**	,419**	1		
7. Reading	505**	508**	,392**	,387**	,372**	,940**	1	
8. Writing	,473**	,450**	,353**	,441**	,417**	,949**	,785**	1

**p<.01, N=476

The results revealed a moderate relationship between preservice teachers' 21st century learner skills and curriculum literacy levels (r= .517; p<.01). In addition, there was a positive and moderate relationship between Cognitive Skills and Curriculum Literacy (r= .505; p<.01). Also, a positive and moderate relationship was found between Autonomous Skills and Curriculum Literacy (r= .394; p<.01). Furthermore, there was a positive and moderate relationship between Collaboration and Flexibility Skills and Curriculum Literacy (r= .439; p<.01) and between Innovativeness Skills and Curriculum Literacy (r= .419; p<.01). These findings indicated that as the participants' 21st century learner skills increased; their curriculum literacy levels increased as well. Finally, a positive relationship was found between curriculum literacy levels and its subscales and 21st-century learning skills and sub-scales.

Table 7. Regression analysis of participants' 21st-century learners' skills use and curriculum literacy levels

Dependent Variable	Independent Variable	B	Standard Error	Beta	t	p	F	R2
Curriculum Literacy	Constants	1,369						
	21st Century Learner's Skills Use	,608	,050	,490	12,236	0,000*	149,721	0.240

*p<.01

Table 7 revealed that 21st-century learning skills significantly predicted curriculum literacy level perceptions (R=.490, R2=.240, F=149.721 p=0.000 p<.01). The beta coefficient of the independent variable, the t value, and significance level showed that 21st century learning skills had a statistically significant effect on curriculum literacy perceptions (t=12.236 p<0.05). A 1-unit increase in the 21st-century skills led to a .490 increase in curriculum literacy perceptions (β=1,369). It was found that 24% of the change in curriculum literacy perceptions was explained.

Discussion and Recommendations

The faculties of education in which preservice teachers are trained should provide 21st-century skills and competencies (Orhan Göksun, 2016). Yıldız (2019) proposed that, as in all fields, the comprehensive, rapid and in-depth information exchange and development in the 21st century brought curriculum literacy to the agenda in the field of education. Curriculum literacy is significant in that it shows how much of the objectives in the curriculum are achieved. Curriculum literacy skills play an important role in the formation of preservice teachers' teaching skills. Briefly, preservice teachers need to have knowledge on curriculum literacy (Snavely 1997; Kapitzke 2001). Teachers who are program literate and develop in this direction will also contribute to their professional life. This study aimed to examine preservice teachers' 21st century learner skills and curriculum literacy level and the relationship between them.

In this study, in which the relationship between preservice teachers' 21st century learner skills and curriculum literacy levels was examined, it was found that their 21st century learner skills were at a high level. This finding is in line with other studies in the literature. For example, Bozkurt (2020), Claro (2009), Engin and Korıcuk (2021), Gülen (2013), Karakaş (2015), Gürültü, Aslan and Alcı (2019), Kıyasoğlu and Çeviker (2020) reported high levels of 21st-century learner skill. However, Aydemir (2020) and Eğmir and Erdem (2021) found that the 21st-century learner skills of preservice teachers were at a moderate level. Some activities can be conducted to increase the 21st-century skills of preservice teachers. For example, Peker (2019) concluded that reading books positively affected preservice teachers' use of 21st-century learner skills. This finding is consistent with studies in the literature (Bozkurt & Çakar, 2016; Canpolat,2021; Eğmir &Erdem,2021; Gürültü, Aslan &Alcı, 2019; Karakaş,2015; Kıyasoğlu & Çeviker Ay 2020; Kozikoğlu & Altunova, 2018; Orhan-Göksün & Kurt, 2017; Önür & Kozikoğlu, 2019; Peker,2019). However, Engin and Korucuk (2021) found a significant difference in favor of male participants. This was because males found more opportunities to develop their responsibility and leadership than females.

It was found in the study that there was no significant difference in terms of the department. Eğmir and Erdem (2021) reported that preservice pre-school teachers had significantly higher skills. Akbay, Sıvacı, and Akbay (2020), on the other hand, found that preservice social studies teachers had higher levels of 21st century skills.

It was also found that preservice teachers' curriculum literacy levels were at a high level. Similarly, studies conducted with prospective teachers (Dilek, 2020; Çetinkaya & Tabak,2019; Şahin,2020) and teachers (Aygün,2019; Erdem & Eğmir, 2018; Gündoğan, 2019; Güneş Şinegove Çakmak, 2021, Süral & Dedebali, 2018; Aslan & Gürlen, 2019; Kuyubaşıoğlu, 2019; Keskin, 2020; Gülpek, 2020, Yılmaz & Kahramanoğlu, 2021) showed that they had high levels of curriculum literacy levels. However, some studies (Kahramanoğlu, 2019; Yıldız, 2019) reported a moderated level of curriculum literacy. In contrast, Gani and Mahjaty (2014) and Opoh and Awhen (2015) stated that teachers' curriculum literacy levels were low. The fact that preservice and in-service teachers have high curriculum literacy is positive for education. Thus, focusing on teaching practices in the education of preservice teachers and directing them to applied courses would develop their curriculum literacy (Carl, 2005).

It was found that the participants' curriculum literacy levels did not significantly differ by gender. In line with this finding, studies in the literature reported that preservice and in-service teachers do not differ by gender (Dilek, 2019; Demir & Toraman, 2021; Gülpek, 2020; Erdem & Eğmir,2018; Keskin, 2020; Tunçer & Şahin,2019). According to Dilek (2020), one of the main reasons why the curriculum literacy of preservice and

in-service teachers does not differ by gender is that they follow current education programs and have adopted the innovations in their fields. Contrary to the findings of the present study, Erdamar (2020) and Ustabulut (2021) found that in-service teachers' curriculum literacy perceptions were higher in male teachers whereas Aygün (2019) and Kahramanoğlu (2019) found that female participants had higher curriculum literacy levels.

The findings revealed that the curriculum literacy of the participants significantly differed by the department. It was found that preservice pre-school teachers and preservice social sciences teachers had higher curriculum literacy levels. The study of Süral and Dedebali (2018) supports this finding. On the other hand, Erdem and Eğmir (2018) found that the preservice teachers at the Turkish Language education department had higher curriculum literacy levels than those at the Mathematics education department. Çetinkaya and Tabak (2019) also demonstrated that curriculum literacy levels of preservice teachers at Classroom Teaching department were higher than those in Pre-school and Mathematics Education departments.
A positive and moderate relationship was found between preservice teachers' 21st century learner skills and curriculum literacy. In addition, there was a moderate relationship between curriculum literacy and Cognitive and Collaboration and Flexibility and Innovativeness sub-scales, and a weak relationship between curriculum literacy and Autonomous sub-scale.

It was found in this study that the participants' 21st century learner skills were a significant predictor of their curriculum literacy levels. Participants' 21st century learner skills explained 24% of curriculum literacy changes. As the participants' 21st century learner skill levels increased, their curriculum literacy levels also increased. It can be said that, through these skills, preservice teachers can better understand the curriculum when they become a teacher in the future. Thus, it can be anticipated that a preservice teacher and in-service teacher who understands the curriculum better and has 21st Learner skills may have a more positive attitude towards the profession. The development of 21st-century learner skills of preservice teachers will pave the way for them to become better curriculum literate, which will also contribute to their professional life. Thus, it can be put forward that they will be more productive while performing in the teaching profession. Therefore, efforts should be made to develop these skills in prospective teachers in undergraduate courses.

Ethical Approval (only for necessary papers)
Ethical permission 22/01/2021-7389 was obtained from Fırat University Social and Human Sciences Scientific Research and Publication Ethics Committee for this research.

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The Impact of Using Model and Augmented Reality Technology on Students' Science Achievement, Motivation, and Interest Levels

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The Impact of Using Model and Augmented Reality Technology on Students' Science Achievement, Motivation, and Interest Levels

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Abstract

In this study, it was aimed to investigate the effects of modelling and the materials designed with augmented reality technology on the academic success of students, their motivation, and their interest levels towards the science course. The study was conducted in 6th grade science units on "Support and Movement Systems" and "Systems in Our Body". In the study, a quasi-experimental design with a pre-test and post-test control group was applied. The study was carried out with three groups: the control group, the augmented reality experimental group, and the modeling experimental group. The research sample consists of a total of 66 students studying at a public middle school in the Küçükçekmece district of İstanbul province during the 2020-2021 academic year. To collect data, a 30-item Science Achievement Test, a 23-item Science Motivation Scale, and a 27-item Science Interest Scale were applied. The Kruskal-Wallis test was applied for multiple comparisons, and Mann-Whitney U tests were carried out for post-hoc comparisons. For intragroup comparisons, Wilcoxon Signed Ranks tests were applied. According to the results of the study, it was concluded that the use of augmented reality and modeling techniques in the science course had a statistically significant effect on the academic success, motivation, and interest of the students towards the science course.

Keywords: Augmented Reality, Modeling, Science Achievement, Interest, Motivation

Introduction

Rapid changes experienced in today's age of science and technology require having an effective science education system. Science education aims to gain the concept of science literacy. In addition to raising scientifically literate individuals, it also aims to provide basic life skills specific to the field of science, such as scientific process, engineering, and design skills. Science education enables individuals to acquire features that they can use in their daily lives such as model building, creativity, entrepreneurship, critical thinking, cooperation, problem solving, and product creation (Alaca, Yaman & Nas, 2020; Bakırcı & Kaplan, 2021; National Research Council [NRC], 2012). Individuals who are scientifically literate can interpret, explain, and evaluate this information by having an idea about scientific developments. They can take initiatives to understand the nature of scientific knowledge by approaching scientific discussions with a critical perspective (NRC, 2007). It can be claimed that the aim of raising individuals with 21st century skills can be achieved by an up-to-date science curriculum, well-trained science teachers, and the use of appropriate teaching methods and techniques. Therefore, individuals should benefit from technology in the process of accessing information, presenting, storing, and transferring information, and should be supported in terms of these features. Competencies such as learning to learn, digital, logical, and spatial thinking are the skills that students will need in the future in terms of their academic, personal, and social development (MoNE, 2018). In the science curriculum, it is aimed to enable individuals to reveal their creativity and be directly involved in the learning process by being aware of their responsibilities, which is in line with the 21st century skills (Akpınar & Ergin, 2005). Moreover, methods and techniques chosen are of great importance, especially in learning difficult or abstract concepts, increasing motivation, academic achievement, or interest in science (Hiğde & Aktamış, 2022; Kang & Keinonen, 2018; Önal & Önal, 2021) besides the skills of science teachers, who are directly involved in the learning process of individuals and responsible for providing better management of education.

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The science courses are generally intertwined with the elements of daily life. More meaningful and permanent learning is provided when students interact with daily life and take an active role in learning by doing and experiencing. Thus, using techniques such as augmented reality (AR) and modeling on science subjects that remain abstract for students may contribute to meaningful and permanent learning. In most cases, individuals cannot visualize the information they need to learn in their minds. In such cases, there is great benefit in using models in education (Benzer & Ünal, 2021; Damerau et. al., 2022; Ke, Sadler, Zangori, & Friedrichsen, 2021; Sarıkaya, Selvi & Doğan Bora, 2004; Yiğit & Akdeniz, 2000). The use of models in education is of great importance in transferring and concretizing the course content to students. Models and modelling should be used while creating a scientific product (Minaslı, 2009). The use of models in the classroom allows students to develop their imaginations and scientific thinking skills while also creating mental models (Çoban, 2009). Science education is a very convenient branch in the use of models due to the subjects it contains and is an area where abstract concepts and events are intense. With regard to this aspect, it is known that students have difficulties in making sense of the course content (Ecevit & Özdemir Şimşek, 2017). Modeling techniques are of great importance for science education at the stage of knowledge creation (Koponen, 2007). Models developed for learning science lessons allow students to explain, define, and generalize scientific subjects. The models used in the course process enable students to visualize the existing model in their minds. Thanks to the models, the event or process to be conveyed is embodied and presented to the student (Gilbert & Boulter, 1998). When looking at the research in the literature, it's clear that individuals' interest in the lesson has increased (Schimmel, 2020) and their cognitive process skills have improved (Gilbert, 1990). Demirel and Altun (2007) stated in their studies that individuals can easily visualize the information they need to learn in their minds, and permanent learning emerges. In many studies, it is seen that significant changes occur in students' attitudes and motivations during the teaching process with models (Çevik, 2018; Özcan, 2016; Ulusoy, 2011; Ünal & Benzer, 2021; Zeytinli-Ünal, 2018). Among other studies, models improve mental skills by increasing academic achievement and increasing three-dimensional thinking (Akıllı, 2011; Akıllı & Seven, 2014; Canlas & Guevarra, 2020; Minaslı, 2009; Özcan, 2016; Vergara-Díaz, Bustamante, Pinto & Cofré, 2020). According to the research, students learn mental abilities such as problem solving, analyzing, and synthesizing because of the use of models in science classes (Günbatar & Sarı, 2005).

Augmented Reality technology enables real and virtual environments to come together to create an environment consisting of video, audio, or three-dimensional animations (Cheng & Tsai, 2013). When the history of this technology is examined, it was first employed in military, industrial, and medical investigations (de Souza Cardoso, Mariano & Zorzal, 2020; Eckert, Volmerg & Friedrich, 2019; Vaughan-Nichols, 2009). At present, it continues to be used in the educational process (Yen, Tsai & Wu, 2013). The most important reason behind the rapid spread and ease of accessibility of AR technology is that it has moved away from high-cost and complex equipment (Wu, Lee, Chang & Liang, 2013). Today, AR applications, which can be easily used in harmony with computers, tablets, and smart phones, can be used by every individual with these devices. The fact that the cost of this technology has become accessible with the development of technology has also positively affected its accessibility in educational environments. Textbooks have begun to be equipped with this technology. AR applications emerge as a technology that makes learning environments more fun and active for students instead of classical education-teaching environments (Birişçi & Karal, 2010; Önal & Önal, 2021). With the use of AR technologies in science education, course content is provided to be more meaningful and permanent. For example, laboratories are of great importance in learning science, but today, laboratory facilities are not available in every school. Even if a laboratory exists, its continuous use is impossible due to a lack of materials (Çallıca, Erol, Sezgin, & Kavcar, 2001; Güzel, 2000; Üce, Özkaya, & Şahin, 2001). The experiments, which must be observed in the laboratory, can be observed by the students with AR technology. Contrary to traditional methods and techniques, the use of technology in science education with AR applications is of great importance in schools where the laboratory environment is inaccessible (Özdener, 2005).

Augmented reality applications are becoming increasingly important in the process of integrating technology into education. With AR technology, opportunities such as video, sound and three-dimensional visuals have started to take place in education more frequently. In science education, it has become one of the elements that will enable students to embody the course content by making use of visual elements while telling a story. When the literature is examined, it has been shown that using AR applications in learning environments improves student success (Abdüsselam & Karal, 2012; Kalemkuş & Kalemkuş, 2022; Kan & Özmen, 2021; Kirikkaya & Basgül, 2019 Özarslan, 2013; Shelton & Hedley, 2002; Zhang, Sung, Hou & Chang, 2014). It is among the other studies that it has an effective role in increasing students' motivation and interest towards the lesson (Arici, Yildirim, Caliklar & Yilmaz, 2019; Delello, 2014; Kirikkaya & Basgül, 2019; Saadon, Ahmad, Pee & Hanapi, 2020). Chang, Chen & Huang (2011) stated in their study that AR applications contribute to effective learning by increasing students' motivation to participate in educational activities. Kececi and his colleagues (2021) found that mobile augmented reality (MAR) applications had a significant impact on academic achievement

levels but did not play a determinant role in the development of the students' attitudes toward science and technology.

The review of the relevant literature indicates that using models as a tool, the modelling process as a method, and AR technology in science education is very important in that they will help students clarify abstract concepts or phenomena in their minds, increase their academic achievement, motivation, and interest in science. However, although various studies have been conducted in different areas of science education, there is only a recent study dealing with the effect of modelling and AR technology on a middle school science topic. In that study, Baba, Zorlu & Zorlu (2022) found that use of AR technology and modeling-based teaching in covering the "Solar System and Eclipses" unit of the science course has positively affected attitudes towards AR applications, academic success levels, and improved 21st-century skills. On the other hand, no study has been found in which the effects of modeling and AR applications are researched separately in the same study. Moreover, the "Support and Movement System" topic in the 6th grade science curriculum has not yet been researched in detail using modelling and AR technology applications. This topic is suitable to be investigated with modelling and AR technology applications. Consequently, the present study aims to fill this gap in the literature. It is also within the scope of the current study that teachers are involved in innovation by giving more space to technology, models, and competencies (learning to learn, digital competency, competencies in science and technology, etc.) in the teaching process, supporting the training of individuals who will gain 21st century skills. The main aim of the study is to investigate how models and materials created with AR technology on the topic of "Support and Movement Systems" in the "Systems in Our Body" unit of the 6th grade science lesson in middle school affect students' academic success as well as their interest and motivation towards the science lesson. In parallel with the purpose of the study, the following research questions and sub-questions will be answered:

The research question is, "Does the use of models and augmented reality technology in science education have an effect on the academic success, motivation, and interest levels of sixth grade middle school students?"

The sub-questions of the research are as follows:

- Is there a statistically significant difference in academic achievement, motivation, and interest in science between the experimental and control group students' pre-test scores?
- Is there a statistically significant difference in academic achievement, motivation, and interest in science between the experimental and control group students' post-test averages?
- Is there a statistically significant difference in academic achievement, motivation, and interest in science between the experimental and control group students' pre-test and post-test scores?

Method

This research was carried out under the quantitative research methodology with a pretest-posttest quasi-experimental design consisting of two experiments and one control group. The quasi-experimental design is often used in studies conducted in the field of education when all variables cannot be controlled (Cohen, Manion, & Marrison, 2000). The sampling method of the research is the variable that cannot be controlled due to the selection of the appropriate sample. The quasi-experimental design facilitates the discovery of the cause-effect relationship between the variables in the research (Büyüköztürk, 2016). The groups that will take part in the study in the quasi-experimental design are formed in advance by the researcher. Experimental and control groups are determined in accordance with the sample of the study. A quasi-experimental design was used since the participants were not selected randomly from the population in this study. According to the results of the statistical analysis of the comparison of the groups at the pre-test, there was no statistically significant difference between the groups. Before starting the research, comparing the groups in terms of pre-test results, and determining their equivalence plays an important role in increasing internal validity (Martella, Nelson, Morgan & Marchand-Martella, 2013). Accordingly, no matching was made between the control and experimental groups, a random selection was made, and the groups were formed.

Two different experimental groups are used in the study. The first experimental group (E1) was formed as an AR group, and the second experimental group (E2) was formed as a modeling group. The application was completed in 4 weeks, with 4 lesson hours per week. The students in the control group (C) performed the activities in the textbook in accordance with the present science curriculum. While students in the first experimental group used materials for AR applications, students in the second experimental group were required to model the skeletal system using modeling techniques.

Table 1. Experimental design of the study

Groups	Pre-test	Procedure	Post-test
Control (C)	Science Motivation Scale (SMS)	Use of Traditional method	Science Motivation Scale (SMS)
	Science Interest Scale (SIS)		Science Interest Scale (SIS)
	Science Achievement Test (SAT)		Science Achievement Test (SAT)
1st Experimental, E1 (Augmented Reality Group)	Science Motivation Scale (SMS)	Use of Augmented Reality Technology	Science Motivation Scale (SMS)
	Science Interest Scale (SIS)		Science Interest Scale (SIS)
	Science Achievement Test (SAT)		Science Achievement Test (SAT)
2nd Experimental, E2 (Modelling Group)	Science Motivation Scale (SMS)	Use of Modelling Technology	Science Motivation Scale (SMS)
	Science Interest Scale (SIS)		Science Interest Scale (SIS)
	Science Achievement Test (SAT)		Science Achievement Test (SAT)

Sample

The research sample consists of sixth-grade students enrolled in a public middle school in Istanbul's Küçükçekmece district during the first semester of the 2020-2021 academic year. 66 students who volunteered to participate in the study were chosen using a convenient sampling method, which is one of the non-random sampling methods. For the researcher, the convenient sampling method is based on accessibility and convenience. Convenient sampling is a method that aims to collect data quickly due to its easy access (Berg, 2001).

Data Collection Tools

Science Achievement Test (SAT), Science Motivation Scale (SMS) and Science Interest Scale (SIS) were used as data collection tools in the research.

Science Achievement Test: Developed by Ermiş (2012), SAT was applied as a pre-test at the beginning of the application and as a post-test at the end of the application to measure the pre-knowledge of the students in the control and experimental groups about the "Support and Movement" system and the learning difference that will occur in the students. SAT consists of 30 multiple-choice questions with 4 options. The mean difficulty index of the original test was 0.47, and the reliability coefficient KR-20 was determined as 0.568. The duration of the SAT is 40 minutes. The researchers applied the Science Achievement Test to a group of 60 students who did not participate in the study. The mean difficulty index and KR 20 value of SAT were calculated as 0.47 and 0.72, respectively.

Science Motivation Scale: Developed by Dede and Yaman (2008), SMS with 23 items on a 5-point Likert-scale was used as a pretest and posttest to assess students' motivation for learning science. The scale consists of "5=Strongly Agree, 4=Agree, 3=Undecided, 2=Disagree, 1=Strongly Disagree". The original reliability coefficient was determined as 0.82. The duration of the test is 20 minutes. In this study, the Cronbach alpha coefficient of SMS was found to be 0.80 by the researchers, which is very close to the original value.

Science Interest Scale: The Science Interest Scale developed by Şimşek and Nuhoğlu (2013) was used to determine the interest of the students in the science lesson. SIS is a 5-point Likert type consisting of "5 = Totally Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree". The scale consists of 27 items. The original reliability coefficient of the scale (Cronbach Alpha) was found to be α=0.79. The reliability coefficient obtained shows that it is a highly reliable scale in the fields of education and social sciences. The application time for SIS is 20 minutes. The reliability coefficient of the scale was similarly calculated by the researchers as α=0.77, which is again very close to the original value.

Analysis of Data

Because the data obtained were not perfectly consistent with the normal distribution (Table 2), and the number of participants in each group was less than 30 ($n<30$), non-parametric tests were chosen (Büyüköztürk, 2016). In the case of a comparison of two or more samples, each independent sample should be distributed normally (Orcan, 2020), which is not the case for the current study. The parametric tests shouldn't be utilized if any of the independent samples deviates from normality, which means if one of the groups is normally distributed and the others are non-normally distributed, the normality assumption is violated (Rietveld & van Hout, 2015). When

comparing the SMS, SIS, and SAT pre-test and post-test scores of experimental and control groups, the Kruskal-Wallis test was used. The Mann Whitney U Test was employed as a "post hoc" test to determine which groups differed from the others after the Kruskal-Wallis test revealed a significant difference. A Wilcoxon Signed Ranks test was used when comparing the pre-test and post-test data in the third sub-problem.

Table 2. Normality test results of the study

Groups	Pre-Post tests	Shapiro-Wilk	df	p
Control (C)	SMS Pre-test	.880	22	.012
	SMS Post-test	.923	22	.088*
	SIS Pre-test	.918	22	.070*
	SIS Post-test	.976	22	.839*
	SAT Pre-test	.939	22	.187*
	SAT Post-test	.956	22	.409*
1st Experimental, E1	SMS Pre-test	.956	22	.418*
	SMS Post-test	.903	22	.034
	SIS Pre-test	.951	22	.324*
	SIS Post-test	.971	22	.739*
	SAT Pre-test	.956	22	.415*
	SAT Post-test	.850	22	.003
2nd Experimental, E2	SMS Pre-test	.967	22	.652*
	SMS Post-test	.876	22	.010
	SIS Pre-test	.959	22	.461*
	SIS Post-test	.917	22	.067*
	SAT Pre-test	.933	22	.139*
	SAT Post-test	.895	22	.024

*p>.05

Implementation Process

The control and experimental groups of the research consisted of 22 students each. The study consists of two experimental groups and one control group. The first experimental group is the AR experimental group, and the second experimental group is the modeling experimental group. The research implementation process was completed in a total of four weeks (16 course hours) out of four course hours per week. During data collection, SAT, SMS, and SIS were applied before and after the study in the AR experimental group, modeling experimental group, and control group. The process was carried out by the same researcher to ensure that different variables did not alter the application process. During the application process, a lesson plan for the skeletal system model and AR t-shirt was prepared in accordance with the materials to be utilized in the study. The related learning outcomes in the science curriculum that were incorporated into the lesson plan are given below.

"F.6.2.1.1. explains the structures of the support and movement system with examples."

a. Bone types are given as short, long, and flat without going into the structure of the bones.
b. Joint types are given without going into details.
c. The working principles of muscle types (voluntary and involuntary) and fatigue conditions are given within the framework of their detailed structures.

The students in the control group performed the activities in the textbook in accordance with the curriculum. While the students in the 1st experimental group used materials for AR technology, the students in the 2nd experimental group designed a model for the skeletal system with the modeling technique. All the scales determined as data collection instruments were delivered to the students in the study to collect pre-test and post-test data.

In the control group (C), before starting the application, SAT, SMS, and SIS were applied to the students to collect the pre-test data. The lecture was given to the control group by using direct lecture and question-answer technique during the application phase, and the students did the activities in the textbook. After explaining the subject area of "Support and Movement System," the post-test data for the control group were collected using the Science Achievement Test, Science Motivation Scale, and Science Interest Scale.

In the first experimental group (E1) in which the AR t-shirt was applied, before starting the application, SAT, SMS, and SIS were applied to the students to collect the pre-test data. The students in the first experimental

group were told about the virtual reality application designed by the researcher with AR technology before the lecture process. In the design process of the mobile application designed with the name of AR t-shirt; Unity 3D Game Development Program (5.2.2), Vuforia SDK (software development kit) and "Android Studio" program for the Android Operating System were used. Our main goal has been to design an application that will attract the attention of students in the AR mobile application developed to convey the subject of "Support and Movement Systems" in the "Systems in Our Body" unit to 6th grade students. In the AR t-shirt application designed with the Unity 3D game development program, a skeletal system photograph was determined to be used as a marker by the researcher. Such a decision was made during the development process, considering that choosing a photograph suitable for the subject would attract the attention of the students more and arouse greater interest in the students compared to the applications made on the data matrix. The photograph, which was decided to be a maker (marker), was turned into a file with a sdk extension compatible with the Unity 3D game development program by making the necessary actions on the Vuforia website. After the marker was created, the photograph was matched with the relevant lecture video and a three-dimensional skeletal system image. There are buttons that allow students to go forward and backward while using the application. While creating the buttons, they were written using the "C#" coding language. With the inclusion of the buttons in the application, it was easier for the students to reach the image they wanted between the video with the lecture and the 3D visual. After the design phase of the application, the material on which the marker will be printed was chosen as a t-shirt. The fact that the material was preferred as a t-shirt instead of a normal piece of paper contributed to the emergence of an educational material designed with wearable technology. In this aspect, it differs from other AR applications used in education. After the design process was completed, it was made compatible with mobile devices using the Android Studio platform. The application will be ready for students to use within a month. During the lecture process, all students were dressed in AR t-shirts to observe with their peers. The mobile AR application was installed on the mobile devices of the students, and they were enabled to use the application. They had the opportunity to observe the 3D skeleton system and the videos with lectures in the application via the camera of any mobile device with the Android operating system on the t-shirt. After the application, which was met with interest by the students, SAT, SMS, and SIS were applied to the students again at the specified times as a post-test.

In the 2nd experimental group (E2) in which the modeling technique was applied, SAT, SMS, and SIS were applied to the students to collect the pre-test data, and then the students were informed about the modeling teaching technique. At the beginning of the lesson, questions were asked by the researcher to measure the students' prior knowledge. The instructions for the skeletal system model to be made during the lesson were explained to the students by the teacher. By using the modeling technique, the students were able to design their own materials during the lesson and to be actively involved in the educational teaching process. At the end of the application process, which the students were very interested in, SAT, SMS, and SIS were applied to the students again at the specified times as a post-test.

Results

In this part of the research, a pre-test was conducted to investigate the effects of using models and materials designed with AR application about support and movement systems in the "Systems in Our Body" unit of a middle school 6th grade science lesson on the academic success of students, their interest and motivation towards the science lesson. The findings were obtained from the Science Motivation Scale (SMS), Science Interest Scale (SIS), and Science Achievement Test (SAT), which were applied as a post-test.

Findings Concerning the First Sub-Question of the Study

To find an answer to the first sub-question, namely "Is there a statistically significant difference in academic achievement, motivation, and interest in science between the experimental and control group students' pre-test scores?" In the research, the Kruskal-Wallis test was performed on the collected pre-test data and the results are given in Table 3.

According to the findings in Table 3, the Science Motivation Scale (SMS), Science Interest Scale (SIS) and Science Achievement Test (SAT) pre-test scores of the students participating in the research were higher than $p>0.05$ ($p=0.124$, $p= 0.842$, $p=0.815$), it is seen that the pre-test results did not differ significantly. These results show that the individuals who will be included in the research are equivalent in terms of science achievement, motivation, and interest levels.

Table 3. Analysis results of SMS, SIS and SAT pre-tests scores of experimental and control groups

Pre-tests	Groups	N	Mean Rank	Kruskal Wallis	Sd	p
Science Motivation Scale (SMS)	1st Experimental, E1	22	33,55	4,178	2	0,124
	2nd Experimental, E2	22	27,59			
	Control (C)	22	39,36			
Science Interest Scale (SIS)	1st Experimental, E1	22	33,20	0,343	2	0,842
	2nd Experimental, E2	22	31,98			
	Control (C)	22	35,32			
Science Achievement Test (SAT)	1st Experimental, E1	22	34,09	0,409	2	0,815
	2nd Experimental, E2	22	31,43			
	Control (C)	22	34,98			

*p<0.05

Findings Concerning the Second Sub-Question of the Study

To find an answer to the second sub-question, namely "Is there a statistically significant difference in academic achievement, motivation, and interest in science between the experimental and control group students' post-test averages?" In the research, the Kruskal-Wallis test was performed on the collected post-test data and the results are given in Table 4.

Table 4. Kruskal Wallis test results of SMS, SIS and SAT post-tests scores of experimental and control groups

Post-tests	Groups	N	Mean Rank	Kruskal Wallis	Sd	p
Science Motivation Scale (SMS)	1st Experimental, E1	22	47,50	44,476	2	0,000*
	2nd Experimental, E2	22	41,50			
	Control (C)	22	11,50			
Science Interest Scale (SIS)	1st Experimental, E1	22	47,64	44,560	2	0,000*
	2nd Experimental, E2	22	41,36			
	Control (C)	22	11,50			
Science Achievement Test (SAT)	1st Experimental, E1	22	38,91	14,831	2	0,001*
	2nd Experimental, E2	22	40,86			
	Control (C)	22	20,73			

*p<0.05

When we examine the findings in Table 4, it is seen that the AR, modeling, and control groups met the p<0.05 value in terms of Science Motivation Scale, Science Interest Scale, and Science Achievement Test post-test scores (p=0.000, p=0.000, p=0.001) and this shows the result that there is a statistically significant difference. A Mann-Whitney U test was used to determine between which groups this significant difference was found. The results of the test are presented in Tables 5, 6, and 7.

Table 5. Mann Whitney U test results of SMS post-test scores of experimental and control groups

Post-test	Groups	N	Mean Rank	Sum of Rank	U	p
Science Motivation Scale (SMS)	1st Experimental, E1	22	22,50	561,0	176,0	0,121
	2nd Experimental, E2	22	19,50	429,0		
	1st Experimental, E1	22	33,50	737,0	0,000	0,000*
	Control (C)	22	11,50	253,0		
	2nd Experimental, E2	22	33,50	737,0	0,000	0,000*
	Control (C)	22	11,50	253,0		

*p<0.05

Considering the statistical value of p<0.05 (p=0.000), it is seen that there is a significant difference between the test results between the students studying with AR in Table 5 and the students who are in the control group and take courses according to the Science curriculum. When we examine the results of the modeling experimental group and the control group, it is seen that there is a significant difference in terms of p<0.05 (p=0.000) statistical value. When we examine the test results of AR and modeling technique, it is seen that there is no

significant difference between the two experimental groups in terms of p>0.05 (p=0.121). According to these results, compared to the control group, the groups taught with AR and modeling techniques have a similar effect on students' motivation towards the science lesson.

Table 6. Mann Whitney U test results of SIS post-test scores of experimental and control groups

Post-test	Groups	N	Mean Rank	Sum of Rank	U	p
Science Interest Scale (SIS)	1st Experimental, E1	22	25,64	564,0	173,0	0,105
	2nd Experimental, E2	22	19,36	426,0		
	1st Experimental, E1	22	33,50	737,0	0,000	0,000*
	Control (C)	22	11,50	253,0		
	2nd Experimental, E2	22	33,50	737,0	0,000	0,000*
	Control (C)	22	11,50	253,0		

*p<0.05

When we examine the findings in Table 6, it is concluded that there is no statistically significant difference p>0.05 (p=0.105) between AR and modeling techniques in terms of Science Interest Scale. This finding shows that the AR and modeling groups affect the interest in science at a similar level in terms of teaching technique. When we continued to analyze the results of the FBI Post-test, a statistically significant difference was found p<0.05 (p=0.000) in the test results applied to the students in the AR and control group and the students in the Modeling and control group. The results of this analysis show that AR and modeling techniques are effective in increasing students' interest in science.

Table 7. Mann Whitney U test results of SAT post-test scores of experimental and control groups

Post-test	Groups	N	Mean Rank	Sum of Rank	U	p
Science Achievement Test (SAT)	1st Experimental,	22	21,66	476,50	223,5	0,662
	2nd Experimental,	22	23,34	513,50		
	1st Experimental,	22	28,75	632,50	104,5	0,001*
	Control (C)	22	16,25	357,50		
	2nd Experimental,	22	29,02	638,50	98,50	0,001*
	Control (C)	22	15,98	351,50		

*p<0.05

When we examine the findings in Table 7, it is seen that there is no statistically significant difference between AR and modeling technique in terms of Science Achievement Test, p>0.05 (0.662). When the Science Achievement Test results of the students in the control group and the AR and modeling groups are compared, it is seen that there is a statistically significant difference, p<0.05 (p=0.001). Students in the AR group and modelling group students scored statistically higher than the students in the control group in the Science Achievement Test.

Findings Regarding the Third Sub-Question of the Study

The third sub-question of the research was namely as follows: “Is there a statistically significant difference in academic achievement, motivation, and interest in science between the experimental and control group students' pre-test and post-test scores?” To find an answer to this sub-question, the pretest-posttest data collected was subjected to the Wilcoxon Signed Ranks test. The findings obtained are presented in the tables below.

When the data in Table 8 are examined, a statistically significant difference (P = 0.000) is found between the SMS pre-test and post-test results of the AR (E1) and modeling (E2) groups. In the control group, in which the SMS test was applied, there was no statistically significant difference (p = 0.066) between the pre-test and post-test results. This situation shows that teaching with a traditional approach does not affect students' motivation towards science courses. On the other hand, it was revealed that AR and modeling positively affected students' motivation towards science lessons.

Table 8. Wilcoxon Signed Ranks test results of SMS pretest-posttest scores of experimental and control groups

Groups	Ranks	N	Mean Rank	Sum of Ranks	Z	p
1st Experimental, E1	Negative	0	0,00	0,00	-4,108	0,000*
	Positive	22	11,50	253,00		
	Ties	0				
	Total	22				
2nd Experimental, E2	Negative	0	0,00	0,00	-4,109	0,000*
	Positive	22	11,50	253,00		
	Ties	0				
	Total	22				
Control, C	Negative	0	0,00	0,00	-1,841	0,066
	Positive	4	2,50	10,00		
	Ties	18				
	Total	22				
*p<0.05			*p<0.05	*p<0.05	*p<0.05	*p<0.05

Table 9. Wilcoxon Signed Ranks test results of SIS pretest-posttest scores of experimental and control groups

Groups	Ranks	N	Mean Rank	Sum of Ranks	Z	p
1st Experimental, E1	Negative	0	0,00	0,00	-4,109	0,000*
	Positive	22	11,50	253,00		
	Ties	0				
	Total	22				
2nd Experimental, E2	Negative	0	0,00	0,00	-4,111	0,000*
	Positive	22	11,50	253,00		
	Ties	0				
	Total	22				
Control, C	Negative	0	0,00	0,00	-3,320	0,001*
	Positive	14	7,50	105,00		
	Ties	8				
	Total	22				

* p<0.05

When the findings in Table 9 were examined, it was found that there was a statistically significant difference at the level of p<0.05 (p=0.000 and p=0.001) between the Science Interest Scale pre-test and post-test scores of the AR, modeling, and control group students. The fact that the sums of positive order differences in the groups (ΣS+ = 253.0, ΣS+ =253.00 and ΣS+ = 105.0) in the groups are larger than the negative order difference sums (ΣS-=0.00), the applied teaching techniques reveal that they are effective in increasing students' interest in science.

Table 10. Wilcoxon Signed Ranks test results of SAT pretest-posttest scores of experimental and control groups

Groups	Ranks	N	Mean Rank	Sum of Ranks	Z	p
1st Experimental, E1	Negative	0	0,00	0,00	-4,116	0,000*
	Positive	22	11,50	253,00		
	Ties	0				
	Total	22				
2nd Experimental, E2	Negative	4	5,88	23,50	-3,347	0,001*
	Positive	18	12,75	229,50		
	Ties	0				
	Total	22				
Control, C	Negative	1	3,00	3,00	-2,373	0,018*
	Positive	8	5,25	42,00		
	Ties	13				
	Total	22				

*p<0.05

When the results obtained are examined, it is seen that the AR, modeling, and control group students' Science Achievement Test, pre-test and post-test, scores were statistically significant; p<0.05 (p=0.000, p=0.001 and p=0.018). At the statistical level, it was concluded that there was a significant difference. Furthermore, the fact that the sums of positive order differences (ΣS+ = 253.0, ΣS+ =229.00) in the groups are greater than the sums

of negative order differences (ΣS-=0.00 and ΣS-=23.50) in the groups, reveals that individuals are effective in increasing their success in science.

Discussion

In this study, the effect of using models and AR applications on students' academic achievement, motivation, and interest levels was examined. In the study, the Science Achievement Test was used to measure academic achievement, and the Science Motivation and Science Interest Scales were used to measure interest and motivation towards science. The study's data were statistically analyzed, and the results were discussed in order to answer the research question.

The first sub-problem of the study, "Is there a significant difference between the pre-test scores of the experimental group and control group students in terms of academic achievement, motivation towards science lessons, and interest towards science lessons?" When the findings obtained to answer the question were examined, it was found that there was no significant difference between the pre-test results of the students who were studying with AR, modeling, and traditional learning methods (Table 3). This finding shows that the experimental groups and control groups formed within the scope of the research are equivalent in terms of science achievement, motivation, and interest levels.

The second sub-problem of the study is, "Is there a significant difference between the post-test averages of the experimental groups and the control group students in terms of academic achievement, motivation towards science lessons, and interest towards science lesson?" The Kruskal-Wallis and Mann-Whitney U tests were applied to the data obtained to find an answer to the question. Analysis results have shown that there is a statistically significant difference between the Science Motivation Scale, Science Interest Scale, and Science Achievement Test post-test scores of the AR experimental group, the modeling experimental group, and the control group students studying with the traditional approach (Table 4). Mann-Whitney U tests were performed to determine between which groups this significant difference was found. Test results showed that there was a statistically significant difference at the $p<0.05$ level between the AR experimental group and the control group in favor of the AR group and between the modeling experimental group and the control group in favor of the modeling group in terms of motivation, interest, and achievement scores towards science (Table 5, 6, and 7). On the other hand, no statistically significant difference was determined between the AR and modeling experimental groups in terms of motivation, interest, and achievement post-test scores. These findings reveal that the AR application and modeling techniques are effective in increasing students' academic success and their interest and motivation towards science compared to the control group, but there is no significant difference between the two techniques in terms of positively affecting the test results. It has not been possible to compare our results with the relevant literature because there is no study in the available literature investigating the effects of AR and modeling techniques separately on learning middle school science topics. However, in a very recent study, Baba, Zorlu & Zorlu (2022) used a similar pretest-posttest quasi-experimental design, consisting of one experimental and one control group to examine the effects of AR and modeling techniques on the "Solar System and Eclipses" unit. Since they have formed the experimental group in a way to investigate the effects of both techniques together, it cannot be said that the design they used is fully compatible with our experimental design. Nevertheless, the research results they have found are similar to our results in terms of increasing academic achievement.

The third sub-problem of the research, "Is there a significant difference between the pre-test and post-test scores of the experimental groups and control group students in terms of their academic achievement, motivation towards science lessons, and interest towards science lessons?" The data collected to answer the question was analyzed with the Wilcoxon Signed Ranks test. Analysis results showed that there was a statistically significant difference at $p<0.05$ level between motivation, interest, and achievement pretest scores and posttest scores of the AR and modeling groups (Tables 8, 9 and 10). There was no statistically significant difference between the pre-test and post-test scores of the control group in which the traditional teaching method was applied. These findings obtained from within-group comparisons show parallelism with the findings of intergroup comparisons carried out within the scope of the second sub-problem. As a result, both intra-group pretest-posttest scores and intergroup posttest score comparisons reveal that AR and modeling techniques positively affect students' academic achievement, interest, and motivation towards science. This situation can be interpreted as the use of AR and modeling activities in the lessons leads to the concentration of the students' attention, thus increasing their interest, motivation, and success in the lesson. In many studies similar to ours in different age groups and different subjects in the literature, it has been determined that the use of models in the education-teaching process leads to an increase in the academic success of individuals and the acquisition of many different skills (Akıllı, 2011; Balkan, 2007; Batı, 2014; Bilal, 2010; Burkaz, 2012; Çoban, 2009; Demirçalı, 2016; Harrison,

2001; Köklü, 2009; Minaslı, 2009; Örnek, 2010; Özcan, 2016; Zeynelgiller, 2006; Zeytinli-Ünal, 2018). Demirel and Altun (2007) stated that the use of models in education provides permanent learning by better understanding the course contents by the students. Teaching science with models contributes to the development of individuals' mental process skills such as analysis, synthesis, evaluation, and problem solving (Günbatar & Sarı, 2005). In science lessons, the teaching methods and techniques that should be used while teaching students are of great importance. The more the course's methods and techniques appeal to the student's sensory organs, the more successful the student will be in the course. The findings we obtained as a result of using the models that can be used in 3D in the course are compatible with the findings of similar studies (Akıllı, 2011; Akıllı & Seven, 2014; Minaslı, 2009; Özcan, 2016). In these studies, it was concluded that the use of three-dimensional models contributed to the development of students' three-dimensional thinking skills by increasing academic success in the course. In another study, Akıllı and Seven (2011) made use of this technology while explaining the structure of the atom to students and concluded that it increased students' academic success. Harrison and Treagust (1998), on the other hand, stated that the use of multiple models in science lessons increased the effectiveness of the education. The use of modeling teaching techniques increases the permanence of the information learned by the students by taking an active role in the course process. Some studies revealing the effect of modeling on students' academic success in science courses support our research results (Çökelez, 2015; Düşkün, 2011; Gümüş, Demir, Koçak, Kaya & Kırıcı, 2008).

In studies where AR technology is used, results have been obtained that individuals using this technology are very satisfied with using this technology and would like to use it again (Abdüsselam & Karal 2012; Kırıkkaya & Şentürk 2018; Özarslan, 2013; Sırakaya, 2015). Küçük (2015) stated that the use of this technology in lessons leads to many positive results, such as creating a sense of reality in students, concretizing abstract elements, and increasing the student's interest, curiosity, and success in the lesson. Similar to the results we have obtained, studies have been found in the literature showing that AR technology is effective in attracting students' attention and increasing their interest and motivation towards the lesson (Arici, Yildirim, Caliklar & Yilmaz, 2019; Kirikkaya & Basgül, 2019; Küçük, 2015; Saadon, Ahmad, Pee & Hanapi, 2020; Tomi & Rambli, 2013). In addition, in parallel with the findings we have obtained in some studies (Kalemkuş & Kalemkuş, 2022; Kan & Özmen, 2021; Kırıkkaya & Şentürk 2018; Kirikkaya & Basgül, 2019; Şahin, 2017), it has been stated that AR technology has a positive effect on student achievement in lessons. In a study conducted by Akçayır and Akçayır (2017), it was determined that the use of AR applications in the education-teaching process met their interest and led to an increase in their academic success since individuals are willing to use mobile devices. In a different study, it was concluded that if AR mobile applications are used in the lessons, the motivation and success of the individuals towards the lesson increase (Erbaş, 2016).

The use of the AR t-shirt in the lesson positively affected the motivation of the students. Students encountered wearable technology for the first time. As a result of the research data, it was seen that the students in the experimental group who used AR material had higher motivation compared to the control group because the application used was fun. The advantages provided to students by the AR application enabled them to have high motivation (Delello, 2014; Özarslan, 2013; Taşkıran, Koral & Bozkurt, 2015; Tian, Endo, Urata, Mouri & Yasuda, 2014). The effect of the AR material on the academic achievement of the students is that they are more successful than the students in the control group. Many academic studies in the literature support the conclusion reached (Abdüsselam & Karal, 2012; Fleck, Simon & Christian Bastien, 2014; Önal & Önal, 2021). As a result of research data, the use of AR and modeling techniques in science education has a positive effect on students' academic achievement and motivation, as well as increases students' interest and attention. Studies that are compatible with the results we obtained are found in the literature (Delello, 2014; İbili & Şahin, 2013; Saadon, Ahmad, Pee, & Hanapi, 2020). The AR and modeling techniques and the materials used in the course process increased the interest of the students towards the science course. With the modeling and AR applications, students took an active role in the course process and their academic achievements improved positively (Baba, Zorlu & Zorlu, 2022; Delello, 2014).

Conclusion and Recommendations

The teaching methods and techniques used in the science course are of great importance in increasing the success of this course. In cases where the achievements in the science education program are abstract, they should be embodied in the minds of the students. In the case of using teaching methods and techniques that will facilitate students' understanding of abstract concepts in this way, it will be easier for individuals to make gains in behavior. Today, with developing technology, the integration of education and technology has gained great importance. Along with the models we use in the classroom, materials such as technological mobile applications and AR applications have begun to support the educational environment in the classroom. Models and AR applications are of great importance for individuals to make sense of abstract concepts. Participation of students

in the lesson is a very effective technique in increasing their interest and motivation in the lesson. When it is desired to simulate how an event happened, models or AR applications can be used.

Students are of the opinion that there are not enough models for the abstract and difficult-to-understand subjects in the textbooks. Activities for AR applications in the textbooks of the Ministry of National Education have begun to take their place in today's books. With the use of students with tablets, technology has become accessible in every part of our country, from east to west. We need to emphasize the importance of developing technological materials in these days when we are fully involved in the integration of education and technology. Based on our data results, we can say that students' interest and motivation towards science increased with the AR t-shirt we designed during the process of carrying out the study. In addition to AR applications, among the other results that we have obtained, modeling increases the interest, motivation, and success of students.

With the use of modeling and AR applications in education, the development of behaviors such as problem solving, analysis, synthesis, and evaluation is provided in individuals. It is of great importance for students to benefit from models and technology in the education process, in the subjects they have difficulty in, in terms of their interest, motivation, and success in the course. While students benefit from modeling, they take an active part in the process, facilitating permanent and effective learning. With the correct use of models and AR applications in educational environments, as in the findings we obtained in our research, it is concluded that students' interest, motivation, and success in science lessons increase.

Some recommendations made in line with the findings obtained from the study are presented below.
• Models and AR applications were separately employed to teach the "Support and Movement System" topic in the 6th grade science curriculum. In each case, students' success, interest, and motivation in science were enhanced. The effect of using models and AR techniques to teach other topics in the science curriculum may also be beneficial to research.
• The study was carried out with 6th grade students. Similar studies can be carried out with students in different grades.
• The study was carried out using a quantitative research methodology with a pretest-posttest quasi-experimental design. A qualitative part can also be added for further research. Thus, students' opinions and views on the modelling and AR application processes can be explored in depth.
• Since the application of these techniques is found to be successful in increasing students' success, interest, and motivation in science, primary science teachers can be encouraged and trained to develop their own AR and modeling materials.
• This study is limited by the fact that only a small number of participants were involved. In order to increase the generalizability, the study can be repeated with a larger sample.

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Author (s) Contribution Rate

The authors contributed equally to the article.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

Ethical permission (Protokol No. 2019/313) was obtained from Bolu Abant İzzet Baysal University Social and Human Sciences Scientific Research and Publication Ethics Committee, for this research.

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Validity and Reliability Study on The Development of Data Literacy Scale for Educators

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Validity and Reliability Study on the Development of Data Literacy Scale for Educators

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Abstract

The purpose of this study is to develop a valid and reliable Likert-type scale that can be used to measure the data literacy skills of educators. In the development process of the scale, after reviewing the relevant literature, a pool of 130 items was designed and presented to the experts for their view. After the evaluation of experts, the content validity rate and content validity indexes of the items were calculated by using the Lawshe method, and 39 items were formed. The draft scale of 39 items was applied to 820 teachers and administrators working in public schools in the 2021-2022 academic year. In order to determine the construct validity of the scale, principal component analysis and factor analysis were performed. As a result of these analyses, a scale consisting of 3 factors and a total of 30 items was developed. For reliability, Cronbach α (.953) a coefficient was calculated for the overall dimensions of the scale and varimax rotation. The results show that the scale is valid and reliable.

Keywords: Data literacy, Scale development, Educational data mining, Data literacy scale

Introduction

The term "data" constitutes the basis of information, which is considered as the most important power and capital of human beings today. The amount of data that is not meaningful on its own and turns into "information" only when interpreted has increased enormously through the development of information and communication technologies. Since the amount of this data is so great and as it is constantly changing, the concepts of big data and big data analysis have emerged. Big data is formed by patterns and templates that cannot be reached with classical mathematical methods, and big data analysis means the extraction of these patterns and templates meaningfully as an important decision-making process today **(**Özen, Kartal & Emre, 2017). When the "data" is mentioned in an educational context, it means systematically collected information that reflects education in school in many ways (Schildkamp & Lai, 2013). Many components, such as test results of students or observations made by teachers (Ikemoto & Marsh, 2007), the frequency of their visits to some platforms or even their facial expressions may be (Özen, Kartal & Emre, 2017) accepted as educational data.

Through the 21st century, the role expected of teachers has also changed significantly. In an age where information increases twice every four years, data becomes more important day by day, it is possible for countries to become information societies with individuals who can use and control this information so that they do not fall behind the world (Drucker,1996). Therefore, educators are expected to develop their 21st century skills. "Data literacy" is the skill required to interpret, evaluate, and make decisions based on data analysis today, where huge amounts of data are collected in almost all institutions thanks to the rapidly developing information technologies in the last 20 years (Bollier, 2010).

Data literacy is defined as "the ability to understand and use data effectively to make decisions." (Mandinach & Gummer, 2013). Mandinach (2012) states that educators should go through stages such as collecting, examining, analyzing, and interpreting data systematically while making data-based decisions. Green, Wilson, Versland, Gibson & Nollmeyer (2015) argue that very few educators, including administrators, have received training on that subject and suggest that professional development policies should be adopted to develop these skills for both teachers and school administrators. Bocala and Boudett (2015) state that the training for developing data literacy skills in education faculties is limited. It is stated here that current teachers must improve their data literacy skills in order to develop teaching strategies (Schildkamp, Karbautzki, & Vanhoof, 2014). Ingram, Louis, and

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Schroeder (2004) indicate that in order to improve the quality of education, educators should develop data-based decision-making skills.

The use of data in education has frequently been emphasized by politicians in the last decade to ensure sustainable development in many areas. Moreover, many governments aiming to take greater responsibility on this issue provide professional learning opportunities for educators to learn how to use data responsibly that is, how to protect students' privacy"to facilitate data-based instructional decision-making" (Mandinach & Gummer, 2016). Carlson, Borman, and Robinson (2011) argue that improving data literacy skills in teachers will have educational outcomes such as developing more effective classroom and teaching practices and ultimately increasing student performance. It is predicted that making decisions based on data in education can help students determine their strengths and weaknesses in learning and determine the appropriate instructional actions for what they need (Hoogland et al. 2016).

Although there are attempts to develop data literacy competencies as part of 21st century skills for both teachers and students in Turkey, the relevant literature does not suggest any instrument to assess and evaluate these competencies. Through this study, it aims to develop a data literacy scale in educators and to contribute to the literature.

21st Century Teacher Skills

The changing role of the teacher throughout the 21st century has changed from being the source of information to being a mediator between knowledge and student. Today, where access to all kinds of resources and information is so common, students have become individuals who can instantly check the accuracy and reliability of the information provided by their teachers. In this context, it is important for teachers to access and gain correct data and transfer it to students by associating it with daily life (Driscoll, 2019). 21st century skills are defined by many international organizations such as P21 (Partnership for 21st Century Learning), OECD (Organization for Economic Co-operation and Development), ASIA Society (Asia Society Partnership for Global Learning), ISTE (International Society for Technology in Education), NCREL (North Central Regional Educational Laboratory), and EU (European Union). According to the definitions put forward by these organizations, the competencies that 21st century teachers need to develop are data literacy and using digital tools to analyze and evaluate data (Anagün, Atalay, Kılıç, & Yaşar, 2016).

The research in the USA and Australia shows that there have been many studies on the use and interpreation of educational data, such as statistical analysis of standard assessment and evaluation results and their display on data walls in teachers' rooms and corridors (Sahlberg & Hasak, 2016). Romero & Ventura (2008) state in their research around the world that educational data analysis applications are more frequently used in regions such as North America, Western Europe, Austria, and New Zealand compared to other countries in the world. According to Long and Siemens (2001), the use of big data in education has a very significant role as a guide in determining the necessary innovations in the curriculum and pedagogical strategies. Among the studies aiming to specify the 21st century skills, Trilling and Fadel (2009) stated that under the term digital literacy, data literacy, media literacy, and information and technology literacy are very fundamental for educators. Wagner (2008) also emphasizes the importance of skills for accessing and analyzing data among the seven skills of the 21st century.

The 21st Century Skills Assessment and Teaching Organization (ATC21S) within Cisco, Intel, and Microsoft has categorized 21st century skills and emphasizes data literacy skills for people as a very significant instrument for the success of institutions (Kyllonen, 2012). Moreover, Hoogland (2016), states that data literacy is a critical skill for the 21st century. He defines the data literacy skill as asking and answering questions about the available data and following the data exploration, the visualization of it to understand things better. Data literacy differs from the data analysis stage at the point that it encompasses the ability to clean and prepare data for analysis by casting a critical eye on the outcomes.

In Turkey, the Ministry of National Education (MEB) stated that teachers should have the competence to analyze and interpret the data after determining the assessment and evaluation methods and techniques within the scope of student development monitoring and evaluation (MEB, 2008). The general qualifications of teachers, which were updated in the year 2017, underlie the teachers' competence to prepare and use measurement and evaluation tools suitable for their developmental characteristics among the professional knowledge and skills related to the 21st century.

Turkey has made many attempts to ensure the integration of changing world conditions into educational institutions with some great projects such as, Movement for Increasing Opportunities and Technology

Improvement (FATİH), Maine, Apple Future Classrooms (Göksun, 2016). The concept of "data literacy" is emphasized under the theme of "Data Based Management" in the 2023 Education Vision Report published in December 2018. The term is quite new for our country and needs to be investigated in detail. "A Competent Data Control Unit" and "Learning Analytics Platform" where the academic data of the students is evaluated together with the data regarding their interests, abilities, and temperaments are among the goals of the Ministry of National Education (2018). These studies show that our country will need more educators specializing in data analysis in the near future. As a result, establishing a data literacy culture and measuring it in educational institutions has become a very fundamental objective for Turkey, as well as in other countries of the world (2023 Education Vision Document, 2018).

Educators' Data Literacy Ability

The term "literacy" is defined by UNESCO (2004) as "the ability to define, understand, interpret, create, and calculate through relevant written and printed sources". Data literacy is defined as "the desire and ability to attract the attention of society through data" (Dağ, 2019). According to Morrow (2018), data literacy is the ability to read, study, analyze, and discuss data. As one of the fundamental competencies of the 21st century, data literacy is defined as knowing how to access data in different ways, asking questions, and making basic statistical analysis (Dağ, 2019).

In recent years, the terms as "data collection" and "data analysis" has been a significant necessity, especially in governmental institutions where a very huge amount of data is gathered. Consequently, a need to benefit from the power of statistics by analyzing the collected data in a swift and meaningful way has arisen. In this context, it has become more important than ever to provide the next generation with statistical analysis knowledge and thinking skills by adapting them to various fields (Aydeniz, 2017). Although many schools, not only in our country but around the world, collect a lot of data about students, they do not have a clear vision of how the collected data can be used to increase student success (Creighton, 2006). Kekahio and Baker (2013) point out that using data to improve educational policies and practices has become a high priority in the context of increasing accountability practices in recent years, but educators do not have sufficient infrastructure in this regard. Accordingly, educators need to gain data literacy skills and raise future generations who are also able to use these skills. In a study by the U.S. Department of Education (2011), teachers responded to scenarios involving hypothetical student data designed to investigate their understanding of the types of data available to support teaching decisions. It was observed that teachers had difficulties to finding data, recognizing different types of data, making appropriate calculations, interpreting data tables and graphs, and applying the findings to improve students' learning.

Green et al. (2016) aimed to improve teachers' three skills in their studies to increase their data literacy level in order to improve their data-based decision-making skills. These skills are, recognizing multiple data sources and identifying how they can be used to improve teaching, discovering how to analyze and interpret data in a way that helps improve teaching; and creating a school team that supports teachers' use of data to improve teaching. The criteria determined for data literacy in educators within the scope of the data-based decision-making applications training program developed by the University of Twente consist of eight steps. These are as follows: defining problems, developing hypotheses or questions, gathering data, data quality control, data analysis, interpretation and conclusion, implementation of improvement measures, and evaluation (Kippers et al.2018).

Mandinach, Friedman, and Gummer (2015) emphasize the importance of data literacy for teachers as a key ability to transform information into actionable teaching knowledge and practices by collecting, analyzing, and interpreting all kinds of data and determining appropriate teaching steps. Accordingly, they also define a teacher with data literacy skills as someone who is able to make his data literacy skills meaningful by relating discipline knowledge and practices, curriculum knowledge, pedagogical content knowledge, and how children learn. Within the educational context where education has turned into an evidence-based profession, data literacy has become a basic skill for teachers and all teachers to apply effective teaching practices (Mandinach & Gummer, 2016). Until today, an effective education policy has not been followed regarding effective data use, which is one of the main determinants of teaching quality in institutions. As a result, data use has been perceived by many teachers as a burden to deal with rather than an instrument to be used to improve the teaching process (Almy, Chong & Dorrington, 2019).

It is known that in our education system (MEB, 2019), which has more than 18 million students and nearly one million teachers as of 2018, educational data has increased very rapidly depending on this number. In particular, digital platforms such as e-school, EBA, DYS, MEBBİS, TEFBİS are known to be very important data sources for the education system (Akgün, 2019). When the data collected on these platforms is not processed

meaningfully, it turns into data stacks that we call "big data". The studies conducted in our country show that the educators in fact have a sufficient amount of data that can be implemented in the decision-making process (Demir, 2009). However, in our country, the competence in "data literacy", which means analyzing and extracting data masses among educators in a meaningful way and attracting the attention of society through these data, is very limited (MEB, 2018). In a study conducted by Özdemir Saylam and Bilen (2018) among educators in 2018, the rate of participants who had an idea about educational data mining was found to be 17%. Considering that this rate is quite low, it is important to develop a policy to empower teachers with data and to ensure that they follow career paths that support their ability to use data to improve teaching. Without the necessary data handling skills, teachers do not have a powerful tool to make the best decisions to improve student achievement (Almy, Chong, & Dorrington, 2019). The current policies implemented to date have mainly focused on the field of measurement and evaluation (MEB, 2017). The importance of data use in educational decision making and in improving the quality of education has not been emphasized or addressed by educational policies yet. Today, the knowledge that educators know about students and education is far beyond their current test scores. They need to know and make sense of how to use a variety of student data in order to improve teaching and student achievement (Almy et al.2019). One of the main steps that Turkey should have taken to compete in the international arena in the field of science and technology in line with the objectives of the 2023 vision is to provide all citizens, not only educators, with data literacy competence. It is of great importance to increase the data literacy level among educators in order to achieve the goal of "making data-based decisions in education" set forth within the scope of the 2023 Education Vision Report.

The first attempt to develop data literacy skills in educators should be to determine their competencies in that subject. However, in our country, a measurement system to determine the teacher's competencies has not yet been available. Issues such as performance evaluation that come up from time to time are also postponed for certain reasons. Accordingly, there is no information about the competencies of teachers in Turkey except for the KPSS scores, in which only general cultural and pedagogical knowledge scores are measured. Considering the systems of countries with high success in exams such as PISA and TIMMS, it is seen that serious studies are carried out in these countries on subjects such as the training, selection, and professional development of teachers. In the study conducted by Aydeniz (2017), it is stated that curriculum reform is one of the main things to be done to adapt to the requirements of the age. Nevertheless, to what extent teachers are competent in statistical thinking and data analysis skills, which are among the subjects that should be added to the curriculum in order to establish the 21st century competencies that students should acquire, is another subject that needs to be investigated. Although many in-service training programs have been planned for the professional development of teachers in recent years, there has been no study on measuring data literacy skills and improving their competencies in this area.

Method

This research was carried out on the screening model. The aim of the study is to develop a valid and reliable scale to measure educators' data literacy levels. The three-stage (the creation of scale items and applying for expert opinion, pilot study, validity and reliability stages (Karasar, 2007), scale development process was followed during the study.

Study Group

The final study group consists of 820 educators who work as teachers or educational administrators in different regions of İstanbul in the 2021-2022 education year. The demographic information of the study group is given in Table 1. The "maximum diversity" sampling method, which is one of the purposive sampling methods, was used to determine the study group. By creating a relatively small sample in the maximum diversity sampling method, it is to reflect the diversity of individuals who may be a party to the problem studied in this sample at the maximum level (Yıldırım and Şimşek, 2016). For this purpose, the questions were sent to a group working in different regions and levels of Istanbul, working in different branches and having different experiences. At the time of data collection, the scale was sent to 1200 targeted people online due to the pandemic, but 820 people responded.

Table 1. The Demographic Information of the Study Group

Variable	Group	f	%
Gender	Woman	593	72,3
	Man	227	27,7
Age	Under 25	20	2,4
	26-35	306	37,3
	36-45	297	36,2
	46-55	168	20,5
	55+	29	3,5
Experience	1-3 years	68	8,3
	3-6 years	91	11,1
	6-9 years	150	18,3
	10+ years	511	62.3
Education	Bachelor Degree	603	73,5
	MA Student	22	5,1
	MA	168	20,5
	PHD Student	7	0,9
Title	Teacher	758	92,4
	Assistant Director	39	4,8
	Director	23	2,8
Institution Type	Official	544	66,3
	Private	276	33,7
Total		820	100

Table 2 shows the branches of the 820 participants. The table shows that maximum diversity among the participants was achieved by including teachers from all fields in the study.

Table 2. The Demographic Information of the Study Gruop According to Their Branches

Branch	f	%
Social Studies	139	17,0
Science Studies	92	28,2
Mathemathics	73	37,1
Foreign Language	117	51,3
Preschoool Teaching	30	55,0
Primary School Teaching	164	75,0
Vocational Courses	71	83,7
Pschological Guidance	62	91,2
Visual Arts / Music / Physical Education	72	17,0
Total	820	100

Scale Development Steps

The Forming of an Item Pool

In the process of scale development, the literature on "data literacy in education" was first reviewed by scanning the local and international studies in the last ten years on the subject. After the expert opinions, new items were added to the items prepared based on the data obtained according to the literature review. As a result, 130 candidate items thought to cover data literacy skills for educators were created.

Expert Opinions

Candidate items were submitted to 11 expert (referee) opinions. Seven of these people are experts in education management; four of them are educators who have completed their expertise in information technologies and data analysis. These experts are currently working as researchers or have their PHD degree at Marmara University, Yıldız Technical University and Hasan Kalyoncu University

In the scoring process of the "Data Literacy Scale for Educators" (DLSFE), reviewers were asked to scale the items to 3 points as (Remove, Review, Remain). In the items that need to be reviewed, changes were made through the opinions of experts. The Lawshe technique (Yurdugül & Bayrak, 2012) was used to determine the content validity rates (CGO) of the items in line with the expert opinions received. For this analysis, the formula [KGO = Nu/(N/2)-1) was used. The CGO indicated in the formula = Content validity rate, Nu = the number of experts who agree with the item and N = the total number of experts. The minimum value of the content validity criterion (CGO) for 11 experts is 0.59 (Ayre & Scally, 2014). As a result of the analysis, some of the items that were deemed irrelevant by the referees were removed, and some of the others were revised. The final 39-item scale was obtained.

The Creation of the Draft Form and the Pilot Study

The draft scale form was prepared by taking into account the cumulative rating scale (Likert-type scale) that allows multiple item use aiming to measure a single structure. The draft form was prepared in the form of (1) I strongly disagree, (2) I do not agree, (3) I am undecided, (4) I agree, (5) I completely agree, in a 5-point likert type. In addition, an "instruction" indicating the purpose of the scale and a "personal information form" were added to the draft form. An ethical consent was also attached to the participants, detailing their rights, including the right to withdraw at any time during the research process. The 39-item draft form was applied to 60 people as a pilot study. The Cronbach alpha reliability value was calculated as.953 which is considered a good value. As a result of the analysis, no item that reduces the reliability of the scale was found.

Study on Validity and Reliability

The draft scale was sent online due to the pandemic to the study group, education administrators and teachers working in public and private schools in different regions of İstanbul in the years 2021-2022. 820 people filled the scales completely. The data obtained from DLSFE were analyzed statistically and first, the construct validity of the scale was examined by performing exploratory factor analysis. Whether the DLSFE is suitable for factor analysis was determined by looking at the results of the Kaiser-Meyer-Olkin (KMO) Coefficient and Bartlett's Sphericity Test. As a result of the analysis, it was seen that the draft scale form was suitable for factoring, and an exploratory factor analysis was performed. Then, the structure of the scale was revealed by rotating the maximum variability (varimax) using the principal component analysis method. The 5 items that were not suitable in terms of factor loadings were eliminated, and the total item correlations of the scale were calculated over the remaining items and tested. For the reliability of the scale, the internal consistency coefficient was calculated with the Cronbach alpha formula, and the Cronbach alpha value was found to be.953.

Findings

An Exploratory Factor Analysis (EFA) was conducted to determine the construct validity of the scale. To decide whether the data set is suitable for factoring, Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were conducted. The findings of the analysis are shown in Table 3.

Table 3: KMO and Bartlett's Test Analysis

Kaiser-Mayer-Olkin (KMO) Measure of Sampling Adequacy		0.923
Bartlett Test of Sphericity	X^2	19105.475
	df	465
	p	0.000*

According to Table 2, the Kaiser-Meyer-Olkin (KMO) test value is.923. This means that scale items are suitable for factoring. Büyüköztürk (2002) states that a KMO value of over.70 means that the scale is suitable for factoring. According to Bartlett's test, the data came from a multidimensional universe ($p<.001$) (Büyüköztürk, 2002).

The type of analysis in which the researcher does not have any information about the number of factors measured by the measuring tool and tries to obtain information about the nature of the factors measured with the measuring tool instead of testing a certain hypothesis is called exploratory factor analysis (Tavşancıl, 2006). In scale development studies, it is aimed to reveal the factor structure with principal component analysis, which is frequently used to test construct validity (Çokluk, Şekercioğlu & Büyüköztürk, 2018).

Confirmatory Factor Analysis

Then, Confirmatory Factor Analysis (CFA) was applied in order to make the confimation of the three-factor structure of the scale (Büyüköztürk, 2012). The model for the three-factor structure, which was determined by EFA as a result, was tested with CFA. The results can be seen in Table 4 below.

Table 4: Goodness-of-fit Values for CFA

Fit Indices	Statistics
CMIN/DF	4.67
RMSEA	0.067
SRMR	0.059
χ^2/d.f	1.784
GFI	0.869
AGFI	0.841
CFI	0.91
NFI	0.97
RFI	0.97

The table 4 indicates that the factor loads, and goodness-of-fit values are within the acceptable levels. The results of the tests show that the developed scale was valid. Also, the variables fit with the dimensions (Yaşlıoğlu, 2017).

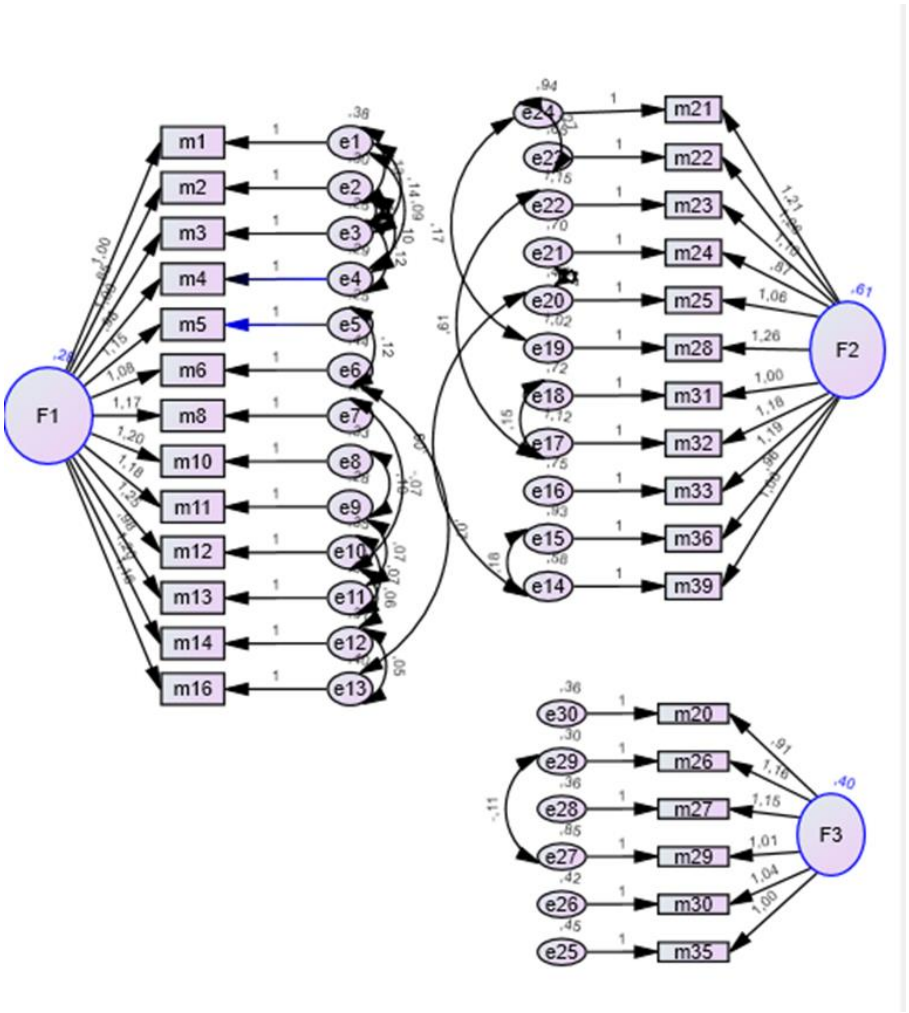

Figure 1. CFA Results

The varimax rotation method is based on the idea that the factors are interrelated and the oblique rotation methods (Büyüköztürk, 2002). As a result of the exploratory factor analysis, it is seen that the scale consists of

three factors. When we look at the percentage of factors explaining the total variance, the first factor explains 43,795, the second factor 10,180, and the third factor, 5,357. Explain why the total variance of factors in the scale is 59.332% in the total rate. The scattering diagram showing the breaking points of the scale is shown in Figure 2.

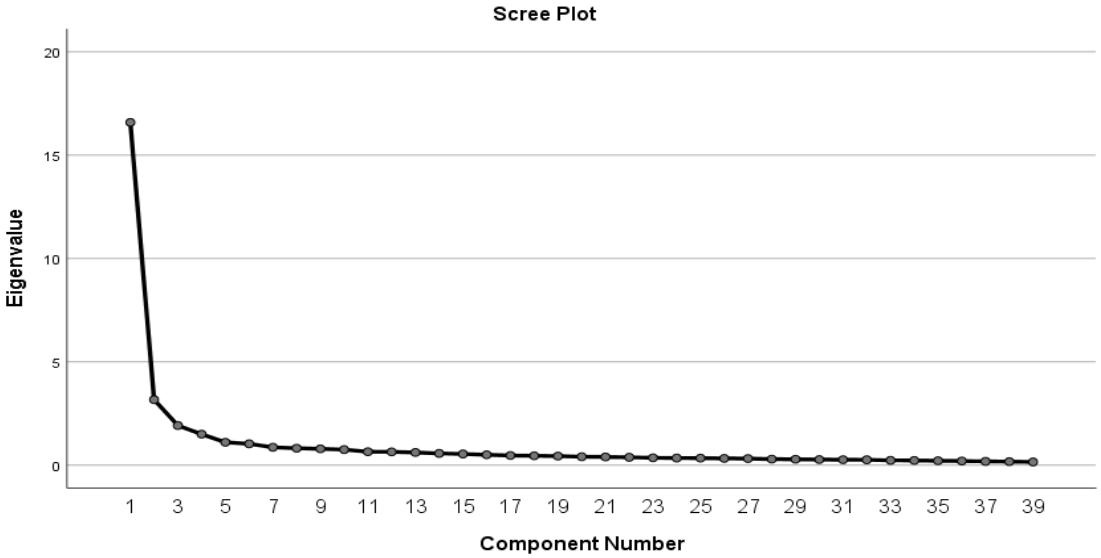

Figure 2. Screeplot Values

When the table is examined, it is seen that there are 3 different breaking points greater than one. High acceleration and rapid declines in the factor line chart are important in deciding the number of important factors (Büyüköztürk, 2002). According to the scatter diagram, there are 3 factors with an eigenvalue greater than one. Accordingly, the scale has 3 factors. The factor values of the loads are shown in Table 5.

Table 6. Factor Loads in Dimensions as a Result of Rotation

	Self-Efficacy	Experience	Attitude
item 1	0,795		
item 2	0,826		
item 3	0,922		
item 4	0,808		
item 5	0,715		
item 6	0,711		
item 8	0,704		
item 10	0,663		
item 11	0,707		
item 12	0,662		
item 13	0,642		
item 14	0,700		
item 16	0,617		
item 21	0,795		
item 22		0,717	
item 23		0,810	
item 24		0,777	
item 25		0,586	
item 28		0,627	
item 31		0,707	
item 32		0,618	
item 33		0,782	
item 36		0,609	
item 39		0,564	
item 20		0,587	
item 26			0,572
item 27			0,683

item 29	0,725
item 30	0,510
item 35	0,552

In scale development studies, factor loadings should be more than.30 (Büyüköztürk, 2002). For this reason, items with a factor load of.30 and above were evaluated. When Table 6 is examined, it is seen that items 1,2,3,4,5,6,8,10,11,12,13,14, and 16 had the highest factor loadings in the first factor. The items 21,22,23,24,25,28,31,32,33,36, and 39 had the highest factor loadings in the second factor. Lastly The items 20,35,26,27,29, and 30 had the highest loadings for the third factor.

Table 6. The Items Take Loadings in Sub Dimensions

Factor	Number of Items	Item Numbers
1	13	1,2,3,4,5,6,8,10,11,12,13,14,16
2	11	21,22,23,24,25,28,31,32,33,36,39
3	6	20,26,27,29,30,35

It has been observed that the scale has a three-factor structure with an eigenvalue greater than 1. The eigenvalues and cumulative variance percentages of the three factors found are shown in Table 7.

Table 7. Sub-Factors and Total Variance Explained

Factor	Eigenvalue	Variance Explained	Cumulative%
1	13,577	43,795	43,795
2	3,577	10,180	53,975
3	1,661	5,357	59,332

When Table 7 is examined, it is seen that the total variance explained under two factors is 53%. It is seen that the first factor has 43.7%, the second factor has 10%, and the third factor has 5% of the explained variance. A common meaning was sought for each item gathered under these three factors, and naming was done according to the literature. In this context, the first factor has been named "self-efficacy", the second factor as " experience", and the third factor was named "attitude". Factor load values, common factor variance, means and standard deviation of the items for factor 1 in the scale are shown in Table 8.

Table 8. Factor Loading Values, Common Factor Variance, Means and Standard Deviation of Items for the Factor 1

Self-Efficacy	Factor1	h^2	X	sd
1. I can distinguish the data I encounter in my daily life (numerical data, character string data, logical data, etc.).	,795	,549	4,489	,818
2. I can tell the difference between quantitative and qualitative data.	,826	,576	4,632	,709
3. I am able to link data together.	,922	,656	4,528	,729
4. I can understand whether the two data points are directly or inversely proportional to each other.	,808	,576	4,543	,748
5. When I need to access some data, I know where to find it.	,715	,654	4,372	,796
6. I can access any kind of data I need.	,711	,548	4,093	,879
8. Data gives me an idea of why some goals are not achieved.	,704	,559	4,193	,821
10. I can extract the data I have collected and achieve meaningful results.	,663	,582	4,198	,857
11. The data not only gives me an idea but also helps me see the gaps and fill them in.	,707	,640	4,364	,823
12. I can interpret tables and graphs containing statistical information.	,662	,576	4,254	,894
13. I think interpreting data is as basic a skill as reading and writing.	,642	,559	4,442	,798
14. I think I am competent in evaluating the data I encounter in my profession.	,700	,615	4,176	,846
16. When I see data about education, I can confirm the accuracy of this information from various sources.	,617	,578	4,030	,888

Factor loading values, common factor variance, means and standard deviation of the items for factor 2 in the scale are shown in Table 9.

Table 9. Factor Loading Values, Common Factor Variance, Means and Standard Deviation of Items for the Factor 2

Experience	Factor2	h^2	X	Sd
21. I am familiar with at least one data analysis program (such as Excel, SPSS, Maxquda, Nvivo, and so on).	,717	,538	3,403	1,361
22. I think I am competent at visualizing data with graphics.	,810	,652	3,231	1,273
23. I know about the concept of data mining.	,777	,587	2,395	1,377
24. I check the course achievement graphics of my students over the digital platforms (e.g., school, eba, zoom, etc.) they use.	,586	,422	4,052	1,077
25. I can make discussions and comments on data analysis.	,627	,639	3,792	1,074
28. I have created graphics and tables using a computer program before.	,707	,513	3,391	1,408
31. I follow the data about education in the world.	,618	,509	3,501	1,150
32. I know the concept of a data set.	,782	,617	2,481	1,404
33.I examine statistically the change in my students' exam scores.	,609	,531	3,489	1,269
36. I think I am familiar with basic statistical concepts (mode, median, standard deviation, arithmetic mean, etc.).	,564	,451	3,563	1,223
39. I use data effectively to achieve a professional set of goals.	,587	,620	3,708	1,090

Factor loading values, common factor variance, means and standard deviation of the items for factor 3 in the scale are shown in Table 10.

Table 10. Factor Loading Values, Common Factor Variance, Means and Standard Deviation of Items for the Factor 3

Attitude	Factor3	h^2	X	Sd
20. I think the data is necessary for the structuring, recording, and easy analysis of the information.	0,572	,536	4,291	,827
26. I find it important that decisions are made based on data in the education system.	0,683	,571	4,214	,911
27. Data analysis skills make me a better educator.	0,725	,523	4,184	,938
29. I think in-service training is necessary in data analysis.	0,510	,329	4,046	1,118
30. When I come across statistical data about education, I examine it carefully.	0,552	,608	4,082	,923
35. Visualizing data is important for seeing meaningful relationships	0,610	,642	4,282	,920

Şencan (2005) states that the model matrix will be sufficient for easier interpretation of the factors. The reliability of the scale was calculated with the Cronbach Alpha internal consistency coefficient. Cronbach Alpha values are shown in Table 11.

Tablo 11. The Cronbach-Alpha Values for Sub-Dimensions of the Data Literacy Scale for Educators

Sub-Dimensions	Cronbach-Alpha
Self-Efficacy	.932
Experience	.913
Attitude	.846
Total Scale	.953

According to Table 11, the reliability coefficent value of the scale sub-dimensions is.932 for the “Self-Efficacy”, .913 for the “Experience” and.846 for the “Attitude“. The value for the whole scale is.953 after eliminating 5 factors according to the factor analysis results.

Discussion, Conclusion and Suggestions

Data literacy skills have become a basic need in today's world, where teachers have to work with increasing

amounts of data every day. Accordingly, data literacy, which must be included in the program in the teacher training process (Mandinach and Gummer, 2016), is a competency that needs to be researched, measured, and discussed in our country as well. Salmacia (2017), found strong agreement that a critical aspect of being a successful teacher is being data-literate. However, how to measure and evaluate this skill is still a matter of debate among researchers.

The aim of this study is to develop a scale to measure the data literacy level of educators and to analyze its validity and reliability. The Data Literacy Scale for Educators is a Likert-type scale with a total of 30 items under three factors. These three factors explain 59% of the total variance. The fact that the scale explains 40% of the general variance is considered sufficient in terms of social sciences (Kline, 2014). The factor load values of the items of attitude towards statistics related to factor analysis are given in Table 7. Items with an item-total correlation of 0.30 and higher indicate that they can measure the feature to be measured (Çokluk, Şekercioğlu & Büyüköztürk, 2012).

The KMO and Barlett tests were used to determine the suitability of the data for factor analysis. The data are suitable for factor analysis if the KMO is greater than 0.60 and the Barlett test is significant (Çokluk, ekerciolu, & Büyüköztürk, 2012). The Kaiser-Meyer-Olkin sample suitability value of 0.960 and the significance level of Bartlett's test of sphericity of 0.000 (for $p \leq 0.05$) indicate that the data are suitable for factor analysis. When the three factors are considered together, they explain 55,554% of the variation in the total variance. This value depends on the load values of the items in each factor and is aimed at being increased (Çokluk, Şekercioğlu & Büyüköztürk 2012). The fact that the explained variance exceeds 50% of the total variance is an important criterion of factor analysis. At this rate, it is an acceptable value within the expected disclosure percentage rates (Tavşancıl, 2014).

The scree plot made to support the eigenvalue assumption is given in Figure 1. When the scree plot, which includes the eigenvalues on the vertical axis and the factors on the horizontal axis, is examined, it is seen that the high-accelerated decline decreases after the third point. From the first point, the downward trend seen from the beginning is indicated by the dots in the degree of contribution to the variance, and each interval between two points represents a factor (Çokluk, Şekercioğlu & Büyüköztürk 2012). As a result of the exploratory factor analysis, three factors with eigenvalues above 1 are named as self-efficacy, experience and attitude. Fifteen items in the self-efficacy dimension reveal the knowledge level of educators in applying data analysis. Thirteen items in the experience dimension reveal the past experiences of educators in data analysis and data literacy in their education or business life. Finally, six items in the attitude dimension reveal the feelings and thoughts of educators about the necessity of data literacy skills in their profession.

The Cronbach Alpha Coefficient was used for the reliability of the scale. Accordingly, the alpha value of the self-efficacy dimension was found to be.953, the alpha value of the experience sub-dimension as.913 and the alpha value of the attitude dimension as.846. The Cronbach Alpha reliability coefficient of the total scale is.952. Cronbach's alpha value of the scale is between $0.81 < \alpha < 1.00$ and this points out that it is highly reliable (Tavşancıl, 2014).

As a result, it can be said that the Data Literacy Scale for Educators is a convenient assessment instrument in terms of validity and reliability. The scale is expected to contribute to the field of data collection by revealing the data literacy level of educators and raising awareness about this issue.

Limitations and Recommendations

The basic limitation of this study is the number of participants. It is recommended that the reliability and validity of the scale be determined in future studies with larger samples, different age groups, and random samples. It is recommended that the survey be conducted in other areas of the country as the current research is limited to İstanbul.

Author (s) Contribution Rate

The authors contributed equally to the article.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

Ethical permission (12.01.2022-215807) was obtained from the Marmara University Research and Publication Ethics Committee for this research.

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