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The relationship between prospective middle school mathematics teachers' critical thinking skills and reflective thinking skills

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The aim of this study was to analyze the relationship between critical thinking skills and reflective thinking skills of prospective middle school mathematics teachers. In addition, it was aimed to examine critical thinking skills and reflective thinking skills of prospective middle school mathematics teachers with regard to some variables (gender, grade level, academic achievement level). This study adopts one of the general survey models: relational survey model. 201 prospective middle school mathematics teachers studying in Elementary Mathematics Teacher Education Program at a state university participated in this study. Reflective Thinking Scale and Critical Thinking Standards Scale were used. For the data analysis, descriptive statistics, independent sample t-test, one-way analysis of variance, correlation analysis, and simple linear regression analysis were used. The findings of this study showed that the prospective teachers' critical thinking skill level is high (agree), reflective thinking skill level is at moderate level (neutral). Critical thinking skills of the prospective teachers were significantly different in terms of gender and academic achievement. On the other hand, reflective thinking skills of the prospective teachers were significantly different in terms of grade level. Besides, there was a positive, significant and moderate relationship between critical thinking skills and reflective thinking skills of the prospective teachers. The prospective teachers' critical thinking skills were the significant predictors of their reflective thinking skills. It was found that critical thinking skills explained 24% of the variance related to reflective thinking skills.

Introduction

Today, the skills required by the workforce are evidently changing. In this context, individuals are expected to deal with new information, to approach problems with a solution and to use information to produce information. Individuals should evaluate the existing information and this evaluation should be in the analysis process. These processes surely require higher order thinking skills. It is important that individuals have critical, analytical,

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creative and reflective thinking skills within the context of higher order thinking skills (Kurt, 2018; OECD, 2017; Pretorius, van Mourik, & Barratt, 2017).

Critical thinking (CT) and reflective thinking (RT) skills, which are the higher order thinking skills, are skills that improve students' learning of mathematics and thus considered as crucial elements of instruction in mathematics education (Cutts, 2018; Sezer, 2008). CT and RT also have an important place in the field of teacher education. The reason behind this is if prospective teachers are raised as reflective and critical thinkers, they can also create classroom environments that will develop the CT and RT skills of students in their own classes (Rott & Leuders, 2017; Williams, 2005). To that end it is considered important to examine the levels of CT and RT skills of prospective mathematics teacher and the relationship between these two skills.

Theoretical background

CT and RT skills and important for mathematics education

In today's world, one of the thinking skills that individuals should have is CT. In the information of the World Economic Forum in 2020, it is seen that the CT skill is at the forefront amongst the skills that an individual should possess (Gray, 2016). CT is to develop a reasonable criterion in order to be able to monitor, analyze and evaluate ideas, opinions, events and facts in order to develop the individual's thinking (Paul & Elder, 2008). CT is also an active and organized mental process that aims to understand the facts and question relationships, taking into account the emotions and thoughts of the individual himself and the individuals with whom he interacts (Rainbolt & Dwyer, 2012). It also includes skills such as applying knowledge, adapting it to novel situations, analyzing causes, and evaluating ideas (Aizikovitsh-Udi & Cheng, 2015).

CT is one of the crucial ways of thinking in terms of mathematics education (Peter, 2012; Rott & Leuders, 2017). Here CT is a judgmental problem-solving process aimed at developing knowledge (Tiruneh, Verburgh, & Elen, 2014). Furthermore, CT is to reach the solution and verify the solution in the problem solving process (Palinussa, 2013). CT, associated with mathematical skills such as problem solving, logical thinking, questioning, and analysis, is an essential part of mathematics education (Su, Ricci, & Mnatsakanian, 2016; Tiruneh et al., 2014; Widana et al., 2018). The literature analysis reveals that mathematics achievement is positively associated with CT (Aizikovitsh & Amit, 2010; Chukwuyenum, 2013; Palinussa, 2013). It is also reported in the relevant literature that CT improves mathematical skills (Aizikovitsh-Udi & Cheng, 2015; Su et al., 2016; Sumarna & Herman, 2017). In addition, CT is not only important for learning mathematics but also for lifelong learning (Nosich, 2009; Williams, 2005).

RT, another high order thinking skill, is the questioning of the individual's experiences, his/her own thoughts, attitudes, knowledge and abilities, while evaluating a situation or problem (Rogers, 2001; Schön, 1987). Dewey (1933) defined RT as a special form of thinking and stated that learning consists of reflections on experiences. In the RT process, the basis of knowledge and beliefs are reviewed and evaluated (Alakawi, 2018). RT includes constructing hypotheses, testing hypotheses, inductive and deductive approaches (Bigge & Shermis, 1999).

RT aims to expand the knowledge of the individual, intending to pave the way for self-

discovery and development (Pretorius & Ford, 2016). Accordingly, RT provides more in-depth learning via enhancing the quality of learning (Kurt, 2018). Thereupon, educational theorists and scholars recommend that students at all grade levels acquire reflective and higher order thinking skills (Dewey, 1933; Kuhn, 1990) as RT improves students' decision making skills (Kuhn, 1990).

One could safely say that RT is an important skill within the framework of mathematics education (Cutts, 2018) as well. According to Mezirow (1991), who argues that the RT process is related to problem solving, RT is the criticism of assumptions in the problem solving process. Schön (1987) emphasizes that the aim of RT is to grasp the problem and solve it effectively. Similarly, Kramarski, Weiss, and Sharon (2013) define RT as a critical review of the problem solving process. Some researchers (e.g., Kızılkaya & Aşkar, 2009; Paul & Elder, 2008) state that in the problem solving process, reflection is activated and RT involves problem solving. In addition, RT is a thinking skill that supports the development of meaningful learning in mathematics (Inoue & Buczynski, 2011). RT also boosts students' interest in solving mathematical problems and encourages students to do so (Cutts, 2018). Thusly, RT provides important opportunities for students to cope with mathematical problem solving. It improves students' thinking on the accuracy of problem solving too (Agustan, Juniati, & Siswono, 2016).

Taking the route of the constructivist approach, the development of CT and RT is considered as one of the aims of education (Başol & Evin-Gencel, 2013; Nosich, 2009). In fact mathematics curriculum in Turkey has been updated based on constructivism (Ministry of National Education [MoNE], 2018). This program aims to educate students as responsible individuals, who can think critically, who own problem solving and decision-making skills. Therefore, it is important to equip students with CT and RT skills in mathematics lessons.

Why are CT and RT skills important for prospective and practicing teachers?

Researchers pinpoint that mentoring and support are essential in the development of CT and RT skills (Alakawi, 2018; Han & Brown, 2013; Khan, 2014; Pretorius & Ford, 2016). As a matter of fact, teachers are expected to create environments where students can express their opinions, evaluate and interpret them (MoNE, 2018). Hence it can be said that teachers have an important mission in developing students' CT and RT skills.

In the mathematics curriculum, the idea that rearing individuals with critical inquiry is fundamental in terms of the development and continuity of the society (MoNE, 2018). The role of teachers in the development of CT skills, which is very effective in students' learning mathematics and problem solving skills, is great. Having said that, first of all, teachers themselves are expected to carry CT skills (Rott & Leuders, 2017; Türnüklü & Yeşildere, 2005) as the design of learning environments to support students' CT takes place through teachers (Halpern, 2014; Han & Brown, 2013). Teachers indeed should play a guiding role for students to question knowledge in learning environments that will develop higher order thinking skills such as CT (Paul & Elder, 2008; Sezer, 2008). Provided that teachers support students to discuss issues in mathematics courses and create instructional plans that are research oriented, students' CT skills can improve (Aizikovitsh-Udi & Cheng, 2015). However, one of the problems reported in educating students who think critically in educational settings is the inadequacy of teachers' CT skills (Pretorius et al., 2017).

Another important thinking skill for teachers and prospective teachers is RT. In the

international literature, it is underpinned that RT skills are one of the qualifications that teachers are to hold in both prospective and in-service teacher education (Lampert-Shepel & Murphy, 2018; National Board for Professional Teaching Standards, 2016; Yu & Chiu, 2019). In the updated "General Competencies of Teaching Profession" in Turkey, it is emphasized that teachers should be individuals who are open to continuous improvement (MoNE, 2017). "Continuous professional development" and "self-assessment" items are among the areas in which the General Competencies for Teaching Profession will be used. Indicating that RT is important for teachers, Dewey (1933) underlined once again that the professional development of teachers should be supported with a reflective approach and embraced this view. Reflective practices are used as a tool for the professional development of teachers (Alakawi, 2018; Yu, 2018). RT helps teachers in the process of examining and evaluating their experiences (Burgoyne & Chuppa-Cornell, 2018). Thence, teachers who can think reflectively learn from their experience and can improve their teaching skills over time (Hayden & Chiu, 2015). In line with what has been stated, it is significant to examine the CT and RT skills of prospective teachers in terms of taking precautionary measures.

Intersections between CT and RT skills

CT and RT, which are considered important in mathematics education, are intertwoven skills (Choy & Oo, 2012). Researchers who define CT often times refer to RT skills (Ennis, 1996; Phan, 2009; 2011). Ennis (1996) discussed CT as a reflective and reasoning skill, concentrating upon deciding what to do or believe. Akin to that according to Phan (2009), CT is considered a higher level of RT, which includes why we perceive something, how we feel, how we behave and what we do. Besides, there are studies in the literature on reflective practices that develop CT. Accordingly, researchers state that the reflection of the individual through their experiences supports the development of CT skills (e.g., Erdogan, 2019; Gibbons & Gray, 2004; Jones, 2003; Yeh, 2004).

RT skills include CT, metacognitive thinking, problem solving and creative thinking. Whence an individual who can think reflectively also thinks critically (Yu, 2018; Yu & Chiu, 2019). It was announced that the opinions of Wilson and Jan (1993) also support this situation. According to Wilson and Jan (1993), RT is related to CT, as it calls for the skills of questioning, evaluation, editing, reasoning, developing hypotheses and predicting for the individual who can think reflectively establishes a relationship between his previous, present and future experiences and his ideas, questions, criticizes and evaluates himself and the situations. Besides, this individual can think critically and creatively. The relationship between RT and CT is also observed in the dimensions of RT. In studies on RT, Hatton and Smith (1995) declared four types of reflections: technical, descriptive, dialogic, critical. Researchers based on Mezirow's (1991) views on RT, classified RT at four different stages: habitual action, understanding, reflection, critical reflection (Kember, McKay, Sinclair, & Frances, 2008; Leung & Kember, 2003; Phan, 2011). According to this classification, critical reflection is the highest level of reflection. The critical reflection process develops the awareness of the teacher of the practices in the teaching process and changes his perspective. Wherefore, critical reflection triggers the teacher to make positive changes in teaching practices (Kember et al., 2008; Leung & Kember, 2003; Yost, Sentner, & Forlenza-Bailey, 2000). In summary, in the literature, it was witnessed that CT and RT skills are theoretically related yet it is considered important to question this relationship statistically.

The rationale and the aim of the study

CT and RT skills of teachers and prospective teachers are considered important in terms of professional development and educational reforms (Aryani, Rais, & Wirawan, 2017; Burgoyne & Chuppa-Cornell, 2018; Choy & Oo, 2012; Ghanizadeh, 2017; Lampert-Shepel & Murphy, 2018; Yeh, 2004; Yu & Chiu, 2019). CT and RT skills, which are associated with the problem solving process and are higher order thinking skills, are also important in terms of mathematics education (Cutts, 2018; MoNE, 2018; Peter, 2012; Rott & Leuders, 2017).

When the literature is analyzed in terms of mathematics education, studies examining CT skills of prospective mathematics teacher are detected (e.g., Deringöl, 2017; Biber, Tuna, & Incikabı, 2013; Incikabı, Tuna, & Biber, 2013; Kandemir, 2017; Türnüklü & Yeşildere, 2005; Yorgancı, 2016; Yüksel, Sarı-Uzun, & Dost, 2013). The results of the existing studies showed that prospective mathematics teachers' CT skills or tendencies were at different levels. It was reported that prospective mathematics teachers' CT skills levels found to be low level (Biber et al., 2013; Incikabi et al., 2013; Yüksel et al., 2013) and lower than moderate or moderate level in some of the studies (Türnüklü & Yeşildere, 2005; Yorgancı, 2016); whereas in some of the others skills of prospective teachers were found high level (Deringöl, 2017; Kandemir, 2017).

In the literature, studies examining RT skills of prospective mathematics teachers also exist (Albayrak, Şimşek, & Yazıcı, 2018; Baki, Aydın-Güç, & Özmen, 2012; Erdoğan & Şengül, 2014; Kandemir, 2015; Kurtuluş & Eryılmaz, 2017; Yenilmez & Turgut, 2016). According to the results, RT skills of prospective mathematics teachers were shared to be low (Baki et al., 2012), moderate (Erdoğan & Şengül, 2014; Yenilmez & Turgut, 2016) or high (Kandemir, 2015).

There are many different variables that affect CT and RT skills, but the effects of these variables are not fully known (Manalo, Kusumi, Koyasu, Michita, & Tanaka, 2013). Based on the analysis of demographic features of prospective teachers, the findings exhibit that prospective teachers' CT or RT skills differ significantly according to gender (e.g., Deringöl, 2017; Erdoğan & Şengül, 2014; McBridge, Xiang, & Wittenburg, 2002; Yorgancı, 2016), grade (e.g., Gilstrap & Dupree, 2008; Yorgancı, 2016; Zembat, Yılmaz, & İlçi-Küsmüş, 2019), and academic achievement (e.g., Kökdemir, 2003; Tümkaya, 2011) whilst some studies report that prospective teachers' CT or RT skills do not differ according to gender (e.g., Incikabı et al., 2013; Leach & Good, 2011; Phan, 2007; 2009), grade (e.g., Aşkın-Tekkol & Bozdemir, 2018; Biber et al., 2013; Incikabi et al., 2013), or academic achievement (e.g., Tekin, Aslan, & Yağız; 2016; Phan, 2007). In sum, due to the contradictory results stated in the literature, studies are needed to extend the literature so as to see how CT and RT skills of prospective teachers differ in terms of gender, grade level, and academic achievement.

It is noteworthy that there is a limited number of studies examining CT and RT skills of prospective mathematics teachers. Moreoever, there are considerable contradictions in the results of the studies. The studies carried out with the prospective mathematics teachers displayed inconsistency calling for more studies. It is important to dwell upon the CT and RT skills levels of prospective teachers who are expected to give their students CT and RT skills in the future, to be able to develop suggestions for taking necessary measures.

It was observed that the studies dealing with the relationship between CT and RT skills were

carried out with prospective primary school teacher, students studying at faculties of engineering and social sciences or guidance and psychological counseling (Aşkın-Tekkol & Bozdemir, 2018; Evin-Gencel & Güzel-Candan, 2014; Göğüş, Göğüş, & Bahadır, 2019). CT and RT skills are critical and necessary skills for prospective mathematics teachers (Cutts, 2018; Inoue & Buczynski, 2011; Lampert-Shepel & Murphy, 2018; Rott & Leuders, 2017). Notwithstanding, to the best of the researcher's knowledge, there is no study in the literature addressing the relationship between CT and RT skills of prospective mathematics teachers. This situation means a gap in the literature. It would arguably uttered then that the present study then has original value with respect to mathematics teachers and their developing CT and RT skills and examining the relationship between these skills.

In this study, it was aimed to examine the relationship between CT and RT thinking skills of prospective middle school mathematics teachers. Additionally, CT and RT skills levels of prospective teachers were analyzed and compared according to the gender, grade level, and academic achievement variables. In the current study, for the general purpose, answers to the following questions were sought:

(1) What are the levels of CT and RT skills of prospective middle school mathematics teachers?
(2) Do the CT and RT skills differ significantly according to the gender variable?
(3) Do the CT and RT skills differ significantly according to the grade level variable?
(4) Do the CT and RT skills differ significantly according to the academic achievement variable?
(5) Is there a relationship between CT and RT skills?
(6) Do CT skills predict RT skills?

Method

Research design

This study adopts one of the general survey models: relational survey model. The relational survey model intends to determine the presence and /or degree of co-variation between two and more variables (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2014). The rationale behind using the relational survey model is that the relationship between CT and RT skills of prospective teachers was examined in the present study.

Participants

201 prospective middle school mathematics teachers studying in Elementary Mathematics Teacher Education Program at a state university in Eastern Anatolia region of Turkey during 2018-2019 academic year participated in this study. 147 (73%) of the participants were female and 54 (17%) were male. Participants' grades included 43% freshmen, 27% sophomores, 16% junior, and 14% senior classes. Participants' ages ranged between 18 and 23 years old. All of the participants took part in the study on a voluntary basis. Thereinafter, the researcher prefers to use 'prospective teacher' to refer prospective middle school mathematics teacher for a shorter and clearer expression.

Data collection tools

Personal information form

In order to obtain personal information of the prospective teachers, a demographic information form was designed. This form contains questions about gender, age, grade level, and academic achievement of the participants.

Critical Thinking Standards Scale (CTSS)

The other scale used in the present study was CTSS which was developed by Aybek, Aslan, Dinçer, and Coşkun-Arısoy (2015) to measure the CT skills of the prospective teachers. CTSS consists of three sub-dimensions (1=Depth, width and competence; 2=Precision and accuracy; 3=Importance, relevance and clarity) and 42 items. Designed as a five-point Likert-type, CTSS has 12 negative statements and the statements are reversed. Items on the scale are as "strongly agree=5, agree=4, neutral=3, disagree=2, strongly disagree=1". Cronbach's Alpha coefficient of the scale was calculated as .75 for the overall scale (Aslan et al., 2015). Furthermore, the Cronbach's Alpha coefficient of the scale was calculated as .73 for present study.

Reflective Thinking Scale (RTS)

RTS, developed by Kember et al. (2000) and adapted to Turkish by Başol and Evin-Gencel (2013) was used to measure RT skills of the prospective teachers in this study. The five-point Likert-type RTS consists of four sub-dimensions (habit, understanding, reflection and critical reflection) and 16 items. The scale has no negative statements and the items are rated as "strongly agree=5, agree=4, neutral=3, disagree=2, strongly disagree=1". The increase in the score obtained from the scale means that the prospective teacher's RT level increased. Reliability coefficient of the scale was .77 in overall scale (Başol & Evin-Gencel, 2013). In this study, it was also determined that the reliability coefficient of RTS was .76 for the overall scale. The data collection tool was applied to the prospective teachers at the end of the spring semester of the aforementioned academic year.

Data analysis

First, the normality of the distribution for CTSS and RTS scores was examined in the data analysis process. Kolmogorov-Smirnov analysis showed that the prospective teachers' scores of CTSS [K-S(z)= .06; p= .20> .05] and RTS [K-S(z)= .05; p= .20> .05] were in accordance with the normal distribution. Therefore, parametric tests were used in the statistical analyses.

Descriptive statistics and independent samples t-test were used to analyze the data having normal distribution. In addition to that, in the case of more than two groups, one-way analysis of variance (ANOVA) test, and Scheffe test were used to determine the group that caused the difference. The .05 significance level was accepted for all tests performed. Evaluation intervals were calculated in order to make sense of averages. Therefore, "4.20-5.00 strongly agree, 3.40-4.19 agree, 2.60-3.39 neutral, 1.80-2.59 disagree, 1.00-1.79 strongly disagree" ranges were taken into consideration in the evaluation of the average scores of CTSS and RTS. Academic achievement levels of prospective teachers were determined by considering their academic averages. Academic averages were evaluated as low if "2.50 and below", moderate if between "2.50-3.00", and high if "3.00 and above". The effect sizes for independent sample t-test and ANOVA were also calculated. The effect size statistics provide

information on the magnitude of the differences between groups (Pallant, 2016). To compare the groups, partial eta squared (η^2) effect size statistics were used. The obtained eta squared values were interpreted as .01 = small effect, .06 = moderate level effect, .14 = big effect (Pallant, 2016).

Furthermore, the relationship between CT and RT skills of the prospective teachers was examined using correlation analysis. Correlation coefficients were interpreted as r= .10- .29 small, .30-.49 moderate, .50- 1.0 large (strong) (Pallant, 2016). Simple linear regression analysis was used to determine the extent to which the level of the prospective teachers' CT skills predicts their RT skills. Assumptions, namely extreme values, normality and linearity, were revised before the regression analysis. Accordingly, it was seen that there are no extreme values both for dependent and independent variables. The distribution of the data obtained from CTSS and RTS was recorded normal. The scatter plot was examined and a linear relationship between the dependent and independent variables was spotted. As a result of all these processes, the data set was found to meet the conditions for regression analysis.

Results

This section presents statistical analyses on the data gained from CTSS and RTS applied to prospective teachers.

Results related to the first sub-problem

Regarding the first sub-problem of the study, descriptive findings related to CT and RT skills of the prospective teachers are presented in Table 1.

Table 1. Descriptive statistics related to CT and RT skills of prospective teachers.

Variables	N	$\overline{x}$	Sd	Min	Max
CT skills	201	3.63	.35	2.79	4.57
RT skills	201	3.08	.52	1.88	4.38

Table 1 shows that the prospective teachers' average CT skills point is 3.63 and RT skills point is 3.08. The results of the study show that prospective teachers express their opinions as "agree" regarding CTSS and "neutral" regarding RTS. This reveals that although the prospective teachers' CT skill level is high (agree), RT skill level is moderate level (neutral).

Results related to the second sub-problem

Addressing the second sub-problem, independent samples t-test results, which were performed to determine whether the CT and RT skills of the prospective teachers differ according to gender, are given in Table 2.

Table 2. Independent samples t test results related to CT and RT skills of prospective teachers in terms of gender.

	Gender	N	$\overline{x}$	Sd	Df	t	p	η^2
CT skills	Female	147	3.71	.33	199	5.06	.00	.11
	Male	54	3.44	.35				
RT skills	Female	147	3.10	.53	199	.65	.52	.00
	Male	54	3.04	.52				

As revealed in Table 2, CT skills of the prospective teachers are significantly different in

terms of gender [$t_{(199)}$= 5.06; p< .05]. This difference in CT skills is in favour of female students. As a result, CT skills of female prospective teachers are higher than male students. Besides being significant, the magnitude of the difference in CT average scores between the groups is moderate (η^2= .11). According to Table 2, RT skills of the prospective teachers are not significantly different in terms of gender [$t_{(199)}$= .65; p> .05]. In addition, the eta squared value reveals that the magnitude of the differences between the RT point average scores regarding the gender is insignificant (η^2= .00).

Results related to the third sub-problem

Within the scope of the third sub-problem of the study, it was investigated if the CT and RT skills of the prospective teacher vary in terms of grade level. The descriptive statistics findings of the prospective teachers' average scores for the CT and RT skills according to grade level are shown in Table 3.

Table 3. Descriptive statistics results for CT and RT skills, by grade level.

Dependent variable	Grade level	N	$\overline{x}$	Sd
CT skills	1	48	3.70	.36
	2	43	3.64	.37
	3	60	3.61	.35
	4	50	3.59	.33
RT skills	1	48	2.81	.39
	2	43	2.88	.53
	3	60	3.20	.48
	4	50	3.38	.48

When Table 3 is analyzed, it was determined that the average scores for the CT skills of prospective teachers were the lowest at the fourth grade level ($\overline{x}$ =3.59) and the highest at the first grade level ($\overline{x}$ =3.70). Although the average scores of prospective teachers for CT skills are close to each other, it can be articulated that as the grade level increases, the average scores decrease. According to Table 3, the lowest average score for prospective teachers' RT skills was found at the first grade level ($\overline{x}$ =2.81). It was figured out that the highest average score was at the fourth grade level ($\overline{x}$ =3.38). Moreover, it was found that as the grade level increased, so did the average scores for RT skills. ANOVA results of prospective teachers' scores for CT and RT skills according to grade level are presented in Table 4.

Table 4. ANOVA results related to CT and RT skills of prospective teachers in terms of grade level.

	Variance source	Sum of squares	df	Mean square	F	p	η^2
CT skills	Between groups	.38	3	.13	1.02	.38	.02
	Within groups	24.46	197	.12			
	Total	24.84	200				
RT skills	Between groups	10.55	3	3.52	15.61	.00	.19
	Within groups	44.39	197	.23			
	Total	54.95	200				

As seen in Table 4, there is no significant difference between prospective teachers' CT skills according to the grade level variable [$F_{(3-197)}$=1.02; p= .38> .05]. In addition to not reaching a

statistically significant difference, it was highlighted that the size of the differences between the groups was slightly above the small level (η^2 = .02). It is observed that the decrease in the CT skill points of the prospective teachers from the first grade to the fourth grade does not make a significant difference between the CT skills according to the grade level. Prospective teachers demonstrate similar characteristics in terms of CT skills. When Table 4 was analyzed, it was found out that prospective teachers' RT skills differed significantly according to grade level [$F_{(3\text{-}197)}$=15.61; p= .00< .05]. Along with reaching statistical significance, it is seen that the real difference in average scores between groups is high (η^2 = .19). In order to determine the source of the differences, prior to the post-hoc analysis, the average scores for the RT skills provided variance homogeneity (F= 1.41; p= .24> .05). To interpret the difference between the grades, the results of the Scheffe test given in Table 5 were examined.

Table 5. Scheffe test results related to RT skills of prospective teachers in terms of grade level.

Grade(I)	Grade(J)	Mean difference(I-J)	p	Difference
1	2	- .07	.93	
	3	- 38	.00*	3>1
	4	- .57	.00*	4>1
2	1	.07	.93	
	3	- .32	.01*	3>2
	4	- .50	.00*	4>2
3	1	.38	.00*	3>1
	2	.32	.01*	3>2
	4	- .18	.25	
4	1	.57	.00*	4>1
	2	.50	.00*	4>2
	3	.18	.25	

According to the results of Scheffe test given in Table 5, RT skill point averages of third and first grade (p= .00< .05), third and second grade (p= .01< .05) prospective teachers differ significantly. This difference is in favour of third grade prospective teachers. Similarly, the RT skill point averages of the fourth and first grade (p= .00< .05), fourth and second grade (p= .00< .05) prospective teachers differ significantly. This difference is in favour of fourth grade prospective teachers.

Results related to the fourth sub-problem

Within the scope of the fourth sub-problem of the study, it was investigated whether prospective teachers' CT and RT skills differ in terms of academic achievement variable. The descriptive statistics findings of the average scores of the prospective teachers towards CT and RT skills according to the academic achievement level are shown in Table 6.

Table 6. Descriptive statistics results for CT and RT skills, by academic achievement level.

Dependent variable	Academic achievement level	N	$\overline{x}$	Sd
CT skills	Low	41	3.53	.37
	Moderate	79	3.53	.35
	High	81	3.78	.29

RT skills	Low	41	3.08	.57
	Moderate	79	3.01	.55
	High	81	3.16	.47

When Table 6 is examined, it was revealed that the prospective teachers' academic scores with high academic achievement were the highest for their CT skills ($\overline{x}$ =3.78). The average scores of prospective teachers with low and moderate academic achievement levels for their C skills were equal ($\overline{x}$ =3.53). It was observed that the highest average score for RT skills belongs to prospective teachers who have high academic achievement ($\overline{x}$ =3.16). While the lowest average score for RT skill was determined among prospective teachers with moderate academic achievement ($\overline{x}$ =3.01), the average scores of prospective teachers with low academic achievement were 3.08. ANOVA results according to the academic achievement level of the prospective teachers' CT and RT skills are presented in Table 7.

Table 7. ANOVA results related to CT and RT skills of prospective teachers in terms of academic achievement level.

	Variance source	Sum of squares	df	Mean square	F	p	η^2
CT skills	Between groups	3.15	2	1.58	14.39	.00	.13
	Within groups	21.69	198	.11			
	Total	24.84	200				
RT skills	Between groups	.88	2	.44	1.60	.20	.02
	Within groups	54.07	198	.27			
	Total	54.95	200				

According to Table 6, a significant difference was diagnosed between the CT skills of prospective teachers according to the academic achievement level variable [$F_{(2-198)}$=14.39; p= .00< .05]. Alongside that it was observed that the effect size was slightly below the high level for the differences between the averages between the groups (η^2= .13). It was recognized that prospective teachers RT skills did not differ significantly according to academic achievement level [$F_{(2-198)}$=1.60; p= .20> .05]. In addition, it was seen that the real difference in average scores between groups was small (η^2= .02). Therefore, it can be said that the RT skills of prospective teachers illustrate similar characteristics with regard to academic achievement variable. Sheffe test was applied to determine the source of the differences of prospective teachers CT skills according to academic achievement variable, and the results are given in Table 8. Together with that before applying the Scheffe test, it was determined that the average scores for the CT skills provided variance homogeneity (F= 2.47; p= .09> .05).

Table 8. Scheffe test results related to CT skills of prospective teachers in terms of academic achievement level.

Achievement(I)	Achievement(J)	Mean difference(I-J)	p	Difference
Low	Moderate	.00	.99	
	High	- .25	.00*	High>Low
Moderate	Low	- .00	.99	
	High	- .26	.00*	High> Moderate
High	Low	.25	.00*	High>Low
	Moderate			

According to the results of Scheffe test given in Table 8, a significant difference was found between the CT skills of the prospective teachers who had academic achievement at high and low level (p= .00< .05); high and moderate level (p= .00< .05). This difference is in favor of prospective teachers who have a high level of academic achievement.

Results related to the fifth sub-problem

Considering the fifth sub-problem, the relationship between CT and RT skills of the prospective teachers was determined by Pearson Correlation Coefficient Test (Table 9).

Table 9. Pearson correlation test results between prospective teachers' CT and RT skills.

		RT skills
CT skills	r	.493**
	p	.000
	N	201

** Correlation is significant at .01 level.

Table 9 points out that there is a positive, significant and moderate relationship between CT skills and RT skills of the prospective teachers (r= .493; p= .00< .01). Thus, it can be said that as the prospective teachers' CT skills augment, so do their RT skills.

Results related to the sixth sub-problem

For the sixth sub-problem, simple linear regression analysis was performed to determine whether CT skills of the prospective teachers predicted RT skills, and the results are presented in Table 10.

Table 10. Simple linear regression analysis results on CT skills predicting RT skills.

Predicted variable	Predicting variable	B	Se	B	t	P
RT skills	Static	.42	.34		1.25	.21
	CT skills	.73	.09	.49	7.99	.00
R= .49 R^2= .24	$F_{(1-199)}$ =63.76	p= .00 < .001				

As seen in Table 10, the prospective teachers' CT skills are the significant predictors of their RT skills (R = .49, R^2 = .24, p< .01). It was found that CT skills explained 24% of the variance related to RT skills. A significant relationship was identified between CT and RT skills [F(1-199) =63.76, p= .00 < .001]. The beta value (β=.49) indicates that this relationship is positive. In relation to the result of the regression analysis, the regression equation predicting the RT skills is as follows:

(RT skills)= .73x(CT skills) + .42

Discussion and conclusion

In this study, the relationship between CT and RT skills of prospective teachers was investigated. In addition, CT and RT skill levels of prospective teachers and whether these skills differ according to gender, grade level, and academic achievement level were analyzed. In the findings of the study, it was discerned that the CT skill levels of prospective teachers were high level (agree). In the literature it is reported that results of various sort are reached for the CT skill levels of prospective mathematics teachers. First of all, the result of the

current study coincides with the results of the studies by Deringöl (2017) and Kandemir (2017). In their studies, the researchers concluded that the CT levels of prospective middle school mathematics teachers were high. Similarly, Türnüklü and Yeşildere (2005) determined that the CT skills levels of prospective teachers were above the moderate level. However, the study results differ from the ones showing that the prospective teachers' CT skills are low or moderate (Biber et al., 2013; Incikabi et al., 2013; Yorgancı, 2016; Yüksel et al., 2013). This difference between study results appear remarkable. It is thought that this difference may result from the measurement tool used or the characteristics of the sample group. A meta-analysis study to determine these differences will provide important contributions to the literature.

As a result of the present study, it was determined that the RT skills of prospective teachers were at a moderate level (neutral). According to this result obtained in the study, it is thought that prospective teachers' RT skills are not as high as desired, and RT skills should be improved since RT skills of prospective teachers can play an effective role on mathematical applications in classroom environment (Sezer, 2008; Suhaimi, Shahrill, Tengah, & Abbas, 2016). This result of the study is consistent with the previous study findings (Baki et al., 2002; Erdoğan & Şengül, 2014; Ng & Tan, 2006; Rogers, 2002; Yenilmez & Turgut, 2016). Baki et al. (2002) and Ng and Tan (2006) found that prospective teachers' RT skills were low in the problem solving process. Similar to this study, Rodgers (2002) arrived at the conclusion that the RT skills of prospective teachers were not sufficient. In the studies that are compatible with the results of this study, it was determined that the RT skills of the prospective teachers are at a moderate level. Notwithstanding, Kandemir (2015) noticed that prospective teachers' RT skills were at a high level. It is thought that this difference may arise from other reasons, such as the personal characteristics of the sample group. It then can be concluded that more studies need to be done about prospective mathematics teachers' RT skills.

Other important results obtained in the study were related to how the CT and RT skills of prospective teachers differ according to the gender variable. According to the findings of the study, the CT skills of female prospective teachers were significantly higher than those of males. Likewise the effect size for this significant difference was moderate. Regarding this result, the study supports the findings of the others, which demonstrated that the female prospective teachers' RT skills were higher than male (Biber et al., 2013; Deringöl, 2017; McBridge et al., 2002; Yorgancı, 2016). According to gender, the finding of prospective teachers' differentiation of CT skills is compatible with Erdem and Yazıcıoğlu's (2015) study result where the gender variable is a meaningful predictor of the prospective teachers' CT skills. Nevertheless in some studies, CT skills of prospective teachers did not differ significantly according to gender (Incikabı et al., 2013; Kandemir, 2017; Leach & Good, 2011; Sarpkaya-Aktaş & Ünlü, 2013; Yüksel et al., 2013). In these studies, the CT skills of prospective teachers according to the gender variable did not vary significantly, but the CT skills of females were higher than the males. King, Wood, and Mines (1990) found that CT skills of male were significantly higher than female. Researchers explain this situation by expressing that different educational experiences encourage men to think critically better.

According to another result of the study, prospective teachers' RT skills did not differ significantly according to gender. This result of the study shows parallelism with the results of the other studies, which speculate that the prospective teachers' RT skills do not differ according to the gender variable (Kandemir, 2015; Phan, 2006; 2007; 2009). Contrarily in some studies, it was determined that female teachers' RT skills were significantly higher than

men (Erdoğan & Şengül, 2014; Gilstrap & Dupree 2008; Tripp, 2011). Phan (2009) stated in his study that institutional cultures can affect the RT skills of female and male prospective teachers. Therefrom, it is difficult to generalize whether the gender variable makes a difference on RT skills. A meta-analysis study on this subject can contribute to the literature.

According to the other findings, there was no significant difference between the CT skills of prospective teachers according to the grade level variable. It is a remarkable result of the study that the prospective teachers' CT skills does not differ significantly according to the grade variable. In the study, it was expected that a difference would emerge in favor of prospective teachers studying in the fourth grade as prospective teachers would be knowledgeable about CT and CT skills would improve thanks to the courses taken until the last year of their education. In teacher training programs, the absence of a course related to CT might have led to such a result. Another reason may be related to the teaching style of academics at the university for the strategies used in learning environments play a role in the development of the CT skill (McMillan, 1987). Tsui (1999) stated that teachers mostly use learning and teaching strategies that focus on students' cognitive development. In addition to these, the following are enlisted as the obstacles for the development of CT: its requiring rather complex mental processes, the existence of problem situations, insufficient space in lessons (King et al., 1990), and instructors' not using teaching methods that improve higher order thinking (Halpern, 2014). It would be fair to say that starting from primary school to the university education obstacles are inherent in the development of individuals' CT skills. This result of the study is compatible with the results of the studies, which share that the prospective teachers' CT skills do not differ according to the grade level variable. In their studies Biber et al. (2013), Incikabi et al. (2013), Sarpkaya-Aktaş and Ünlü (2013), and Yüksel et al. (2013), showed that prospective mathematics teachers' CT skills did not differ significantly from grade level. Besides, Erdem and Yazıcıoğlu (2015) stated that grade level is not a significant predictor of prospective teachers' CT skills. There are also studies whose results in terms of grade level variable are incompatible with the results obtained in the recent study (e.g., Gilstrap & Dupree, 2008; Kandemir, 2017; Shin, Lee, Ha, & Kin, 2006; Yorgancı, 2016). In these studies, a significant difference was found in the CT skills of prospective teachers according to the grade level variable.

In light of the analysis of the data obtained from the study, a statistically significant difference was found between the RT skills of prospective teachers according to their grade levels. According to the grade level, the RT skill of the prospective teachers showed an increasing tendency, from the first grade to the fourth grade. The RT skills of third grade prospective teachers were significantly higher than both first and second grade prospective teachers. In a similar fashion, RT skills of fourth grade prospective teachers were found to be significantly higher than both first and second grade prospective teachers. According to the grade level, it is believed that the courses such as special teaching methods, school experiment, and teaching practice that prospective mathematics teachers encounter in the third and fourth grades, can indeed be effective in differentiating the RT skills of prospective teachers. The content of these courses necessitate that prospective teachers are active participants carrying out observations and gaining teaching experience by presenting a course. In all respects for the development of RT, the active participation of the individual in the learning process is vital (Alakawi, 2018; Pretorius et al., 2017). It also includes questioning RT experiences (Choy & Oo, 2012).

This result of the study is in line with the study result of Zembat et al. (2019), who determined that RT skills of prospective teachers differ according to grade level. In like manner, this

result of the study differs from the results of the others, which indicate that the prospective teachers' RT skills do not differ according to the grade level (e.g., Aşkın-Tekkol & Bozdemir, 2018; Aydın & Çelik, 2013; Elmalı & Balkan-Kıyıcı, 2018; Uluçınar-Sağır, Aslan, Bertiz, & Öner-Armağan, 2016). In previous studies, prospective teachers being in different branches other than mathematics branch can be considered as the reason for this difference in study results.

Another result that emerged in this study pertains to the fourth sub-problem of the study: There is a significant difference between prospective teachers' academic achievement levels and CT skills. CT skills of prospective teachers with high academic achievement are significantly higher than prospective teachers with low and moderate academic achievement. This result of the study is consistent with the results of Kökdemir (2003), and Tümkaya (2011). Kökdemir (2003) manifested that there is a linear relationship between academic achievement and CT. Accordingly, as the CT score of university students increases, academic achievement will increase. Tümkaya (2011), on the other hand, found that the CT skills of university students differ significantly in favor of successful students. Ennis (1996) stated features depicting CT such as analytics, curiosity, self-confidence, increased academic achievement. This result reached in the study contradicts with study result of Tekin et al. (2016) who determined that CT tendencies of science prospective teacher did not differ significantly according to academic achievement variable. It is thought that study results may differ due to reasons such as the branch of the sample group and the courses taken in undergraduate education.

According to another result reached in the study, no statistically significant difference was found between the prospective teachers' academic achievement levels and RT skills. Based on this result of the study, it can be said that the academic achievement parameter is not a factor in the RT skills of prospective teachers. The result of Phan's (2007) study supports this argument. In a longitudinal study conducted by Phan (2007) beginning from the first year of the education of mathematics students, RT did not change depending on academic achievement. Burgoyne and Chuppa-Cornell (2018) emphasize that RT skills are beneficial to teachers in terms of personal and professional development. RT is a necessary skill as well as professional development, social life and many other areas of life (Collin, Karsenti, & Komis, 2013). Based on all these views, it can be said that RT is a skill that all prospective teachers should have, regardless of academic achievement level.

Regarding the fifth sub-problem of the study, a positive, moderate and significant relationship was found between the CT and RT skills of the prospective teachers. Based on this result, it can be said that prospective teachers with high CT skills may also have high RT skills. This result of the study supports the findings of the study, which showed that the CT and RT skills differed together (Aşkın-Tekkol & Bozdemir, 2018; Colley, Bilics, & Lerch, 2012; Evin-Gencel & Güzel-Candan, 2014).

Regression analysis related to the sixth sub-problem of the study showed that the CT skills constitute the variable that explains the RT skills. This finding theoretically supports the similarities expressed for the two thinking skills. Wilson and Jan (1993) once defined the CT and RT skills as overlapping skills. These study results support the study results, which reveal that CT enriches RT (Leung & Kember, 2003; Mezirow, 1991; Phan 2009; 2011, Yost et al., 2000). The results of this study also coincide with the findings of the study showing that CT skills are a significant predictor of RT skills (Evin-Gencel & Güzel-Candan, 2014; Göğüş et al., 2019). On the other hand, Ghanizadeh (2017) states that, contrary to the result of this

study, RT predicts CT.

Limitations and recommendations

Prospective teachers will learn to question their experiences as they develop RT skills. Bearing in mind this when they start teaching, they can improve their teaching practices in their classrooms (Hayden & Chiu, 2015; Yu & Chiu, 2019). Similarly, CT skills of prospective teachers can develop through monitoring, evaluating and reflecting on the problem solving process (Rott & Leuders, 2017). In this context, it is recommended to include theoretical and applied undergraduate courses in education faculties that foster CT and RT skills; models and strategies to support their development to the fullest extent.

In this study, the CT and RT skills of prospective teachers are examined according to the gender, grade and academic achievement variables, which make up the limitation of the study. Therefore, CT and RT skills of prospective teachers can be examined according to some other variables (e.g., book reading rate, parents' education level and so on). It is recommended to conduct meta-analysis studies examining how prospective teachers differentiate according to CT and RT skill levels, gender, grade level variable.

In this study, it was investigated whether CT skills predicted RT skills. By examining CT and RT together, these variables can be targeted for future research, such as mathematics achievement, mathematics self-concept, metacognition, self-regulation. In addition, examining the relationship of these variables in different universes and samples will be a continuation of the study. Last but not the least in studies in which CT and RT skills are to be examined, a need for in-depth interpretation of quantitative data by means of qualitative data in the form of mixed research patterns is obvious.

Since the study is carried out on prospective teachers, similar studies in the future can be carried out on different samples such as primary, middle, or high school students and teachers. Thus, the generalizability of the results can also be examined. In recent years, it is emphasized that the skills of CT and RT in medical education are necessary skills in both teaching and treating processes (Forrest, 2008). In future studies, the model results can be compared by repeating the research this time through students studying in different fields such as medical education and engineering.

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