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RELATIONSHIP BETWEEN PROSPECTIVE MIDDLE SCHOOL MATHEMATICS TEACHERS' LOGICAL AND REFLECTIVE THINKING SKILLS

Prof. Dr. Kürşat Yenilmez
Eskisehir Osmangazi University
kyenilmez@ogu.edu.tr

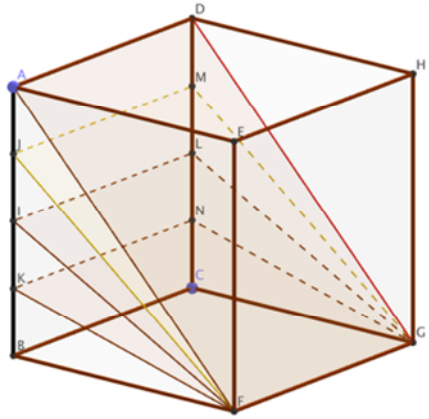
Assist. Prof. Dr. Melih Turgut
Eskisehir Osmangazi University
mturgut@ogu.edu.tr

Abstract
The aim of this research is to explore relationship between prospective middle school mathematics teachers' logical and reflective thinking skills. A total of 165 prospective mathematics teachers (111 female) enrolled to a government university's faculty of education were volunteered to participate in the study. In this correlational study, the data were collected through logical thinking test and reflective thinking skill scale towards problem solving. Descriptive statistics, normal distribution tests and Spearman correlation coefficient were used to analyze the data. According to results, prospective middle school mathematics teachers' logical thinking skills were high, while their reflective thinking skills were moderate level. Moreover, prospective middle school mathematics teachers' logical thinking skills were negatively correlated to evaluation factor and entire reflective thinking skills scale.

Keywords: Logical thinking skill, Reflective thinking skill, Prospective mathematics teacher.

INTRODUCTION

Logical thinking skill (LTS) can be expressed as an amalgam of different kind sub–skills such that *relational thinking*, *reasoning on variables* (not specifically to mathematics), *probabilistic reasoning*, *combinatorial thinking*, *formal reasoning* and (a kind of) *critical thinking* (İncikapı, Tuna, and Biber, 2013; Tobin and Capie, 1981; Yenilmez, Sungur, and Tekkaya, 2005). Although some of these terms are being used interchangeably, the core process in LTS is *reasoning*. Consequently, all level curriculums from preschool to university consider LTS by including carefully–designed tasks to improve students' LTS, because it is in relation to students' cognitive development and also cognitive steps for *problem solving*. For example, applications of mathematics course of Turkish middle school mathematics curriculum (MEB, 2013) points out similar aims, for instance, the development of mathematical experience through problem solving and problem posing, reasoning and relating mathematical concepts and also making connection such concepts with daily life. These aims can be considered as a part of LTS and those also appear in high-level mathematics. Let us give a general example and an example from calculus. Consider the following figure and the task (Figure 1).



Task: *Imagine that you have two different toy cars and one is heavier than the other. How do you use the surfaces in the figure to find which one is faster on reaching the ground? Explain your conjectures.*

Figure 1: A specific task where LTS interlaces with different kinds of reasoning
(Source: Developed in terms of Dynamic Geometry Software)

Same figure can also be used for an advanced level calculus task: "The cube in the figure has 4 cm for each edge and AB and CD are divided into four congruent parts. Suppose that, after one second, point A goes to J, D goes to M; at the end of the next second, J goes to I, M goes to L, … and so on. Can you formulate the change of area of rectangles DAFG, MJFG, …, ?" Although the first task seems a little far away from mathematical reasoning, the subject needs to use his/her relational thinking and combinatorial reasoning. In the second task, the subject needs to use differentiation, where he or she first should define the co-variation and variables. But in both tasks, hypothetically, the subject would use another skill for *reflection* for determining a strategy to solve task. This brings us to speak about concept of *reflective thinking skill*.

Reflective thinking skill (RTS) can be expressed through a combination of questioning, reasoning and evaluation (Kızılkaya and Askar, 2009) (which we considered in this proceeding), although the researchers use different terminologies corresponding to RTS. Because RTS is also something about making logical choices (Köksal and Demirel, 2008), the notion of *reflection* underpins the RTS. Rodgers (2002) elaborated four criteria for Dewey's notion of reflection (p. 845):

- Reflection is a product of individual's phenomenological experiences. Consequently, it is a kind *meaning–making* process.
- Reflection is a kind of scientific thought; it is systematic and occurs following some specific steps derived from problem solving experiences.
- Reflection appears when the individual interacts with a social–communicated environment.
- Reflection needs having positive attitude for giving value for personal and intellectual growth.

Through comparing the definitions of LTS and RTS, some common—but overlapping—keywords become apparent: (i) *Experience*, because both skills are based on individuals' observations, discussions and meaning–making etc. (ii) *Problem solving*, this is a kind of employment of scientific inquiry steps. (iii) *Reasoning*, this process includes the use of different synthesis techniques for meaning–making. Considering this, which our research aim was based on, we postulated that individuals' LTS and RTS would correlate. However, this proceeding is a part of an extensive research, since it would be meaningful to address general viewpoint of the project.

The Project

Research results coming from literature provide evidence that LT correlates with mathematical reasoning and spatial thinking (Delialioğlu, 1996; Kayhan, 2005). For one living in three-dimensional world always uses spatial reasoning to understand spatial environment. Therefore, the nature of spatial reasoning could interlace with LT. For example, see the following figure (Figure 2).

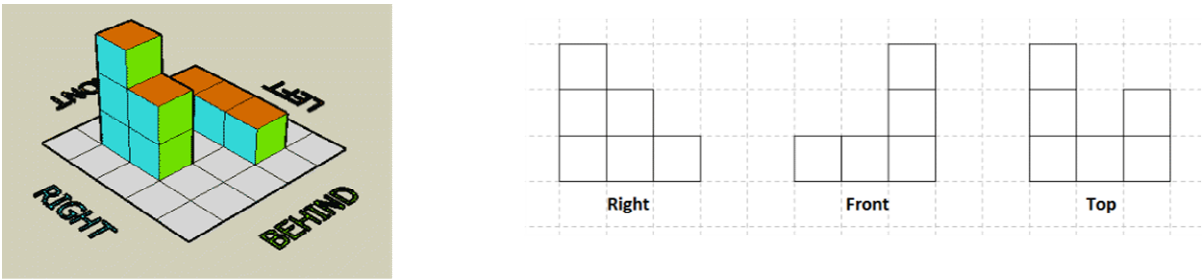


Figure 2: Spatial task that one could solve through using his/her LT
(Source: reproduced from Turgut and Uygan, 2013)

The task in this figure is: "How do you construct a geometric figure with less unit cubes to obtain the views in the right side of the figure?" In this task, the subject first has to visualize the building from different viewpoints, and has to explore possibilities because there is no limitation for gravity since it is not a building. In other words, the subject would use his/her combinatorial thinking. This insight and our aforementioned hypothesis implied us to research prospective teachers' LTS, spatial thinking skills (STS), and RTS with respect to a bunch of independent variables. In order to picture out the effects of department, gender and academic performance on

prospective middle school mathematics and science teachers' LTS and STS, we first reported (Turgut, Yenilmez, and Balbağ, submitted). We hypothesized that it would be important to explore prospective teachers' case, because they will teach not only mathematics soon, but also will teach how to think logically and spatially. However, in this proceeding, we only present a part of the project for relationship between prospective middle school mathematics teachers' LTS and RTS. Therefore, we focused the following research questions:

- What are the level of prospective middle school mathematics teachers' LTS and RTS?
- Do prospective middle school mathematics teachers' LTS and RTS correlated?

METHOD

Research Model and Participants

This research (also the whole project) is a correlational study embedded in quantitative paradigm. Participants of the study were 165 (111 female and 54 male; 79 freshman, 86 sophomore level) prospective middle school mathematics teachers enrolled to mathematics education program of a faculty of education in a government university in central Turkey.

Measures

LTS Test: LTS test was developed by Tobin and Capie (1981) and this test was adapted into Turkish by Geban, Askar, and Özkan (1992). The test includes 10 tasks with measuring five different sub–skills: (i) controlling variables (the first and the second task), (ii) proportional reasoning (the third and the fourth task), (iii) probabilistic reasoning (the fifth and the sixth task), (iv) relational reasoning (the seventh and the eighth task) and (v) combinatorial reasoning (the ninth and the tenth task). Reliability coefficient of the test was found by Geban et al. (1992) as .81. 20 minutes was given to students to complete the test. Maximum score of the test was 18.

RTS Scale: RTS towards problem solving scale was developed by Kızılkaya and Askar (2009). The scale includes 14 items with three factors. The first factor is reasoning (5 items), the second factor is questioning (4 items) and the third factor is evaluation (5 items). Maximum score of the scale was 70. The researchers reported the reliability coefficient of the scale as .83.

The Data and Analysis

The authors collected the data in spring semester of 2013–2014 educational year. The scales were merged into a single form, where the participants also gave details (for the whole project) about their gender, preschool education, department, class level and their GPA. Next, LTS test results were checked one by one and coded into SPSS with independent variables. Secondly, RTS scale's scores were calculated for each factor and for the entire scale. Finally, the data were analyzed through descriptive statistics, normal distribution tests and Spearman's rho correlation coefficient tools of SPSS 21.0 version.

RESULTS

In order to determine levels of LTS and RTS of prospective middle school mathematics teachers (with respect to first research question), we employed descriptive statistics techniques. Table 1 presents the results.

Table 1: Descriptive statistics results

Measure	$\overline{X}$	*SD*
LTS Test	16.06	1.99
Reasoning	11.33	2.67
Evaluation	12.61	2.83
Questioning	8.67	2.44
RTS Scale	32.65	6.80

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According to Table 1, prospective middle school mathematics teachers' LTS level was high, since it was close to 18. However, their RTS were moderate level, since total scale score was close to 35. As a next step, in order to investigate the relationship between LTS and RTS of the participants, we used Kolmogorov – Smirnov test to check normal distribution of the collected data. Table 2 presents results of the analysis.

Table 2: Normal distribution analysis results

		Kolmogorov–Smirnov	
Measure	*Statistics*	*df*	*Sig.*
LTS Test	.298	165	**.000**
Reasoning	.115	165	**.000**
Evaluation	.136	165	**.000**
Questioning	.126	165	**.000**
RTS Scale	.086	165	**.005**

Table 2 indicates that the dependent variables' scores were not distributed normally (all were significant, p<.05). Consequently, in order to answer research question 2, we considered a nonparametric correlation analysis: Spearman's rho coefficient. Table 3 presents (nonparametric) correlations between LTS and RTS scores including factors of the RTS scale.

Table 3: Spearman's rho coefficients of LTS and RTS scores

Measure	*LTS Test*	*Reasoning*	*Evaluation*	*Questioning*	*RTS Scale*
LTS Test	1				
Reasoning	—.074	1			
Evaluation	—.192*	.502**	1		
Questioning	—.121	.632**	.533**	1	
RTS Scale	—.164*	.834**	.819**	.831**	1

* Correlation is significant at .05 level.
** Correlation is significant at .01 level.

Table 3 shows that, while LTS test scores was not correlated to reasoning scores $(r = -.074, p > .05)$, there was a negative, but weak correlation between LTS test scores and evaluation factor scores $(r = -.192, p < .05)$. Moreover, LTS test scores was also not correlated to questioning scores of the RTS scale $(r = -.121, p > .05)$, where LTS scores was negatively correlated to overall RTS scale scores $(r = -.164, p < .05)$. However, as expected, there was a strong and positive correlation between: (a) reasoning and evaluation $(r = .502, p < .01)$; (b) reasoning and questioning $(r = .632, p < .01)$, (c) reasoning and the overall scale $(r = .834, p < .01)$. Similarly, there was a strong and positive correlation between: (d) evaluation and questioning $(r = .533, p < .01)$, (e) evaluation and the overall scale $(r = .819, p < .01)$, (f) questioning and the overall scale $(r = .831, p < .01)$.

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This paper investigated relationship between prospective middle school mathematics teachers' LTS and RTS. According to descriptive results, participants LTS scores were high, which is inconsistent with research results coming from literature (İncikapı et al., 2013; Tuna, Biber, and İncikapı,2013), because, researchers observed a low level LTS for prospective middle school mathematics teachers. As we pointed out in the first report (Turgut et al., submitted), this could be due to LTS test could be insufficient for evaluating undergraduates' LTS. Consequently, a further item and concurrent validity analyses studies are needed to discuss the LTS test.

Secondly, we found that prospective middle school mathematics teachers RTS were moderate level. This result seems consistent with research results for participants enrolled to same program (Baki, Aydın Güç, and Özmen,

2012), and also consistent with results for prospective social science teachers (Gedik, Akhan, and Kılıçoğlu, 2014). For further deep elaborations to explore students' RTS, the use of other instruments with qualitative paradigm could be a heuristic tool to understand processes. Instruments that are in (Baki et al., 2012; Gedik et al., 2014) could be helpful for this purpose.

As a third result, we interestingly observed negative correlation between participants' LTS and RTS; consequently, we rejected our hypothesis that LTS would correlate to RTS. This result also could be due to LTS test as we mentioned above, whose results were commonly inconsistent with similar studies. However, another interesting result was expressed by İncikapı et al. (2013), where they found a negative correlation between prospective middle school mathematics teachers' critical thinking skills and LTS, although they used similar but different test for measuring LTS. Therefore, further but with qualitative lens, some investigations are needed to understand such interesting results. Because, like in the present study, a hypothesis could be established through definitions of mentioned specific skills: critical thinking skills are positively correlated to LTS.

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