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INVESTIGATION OF HIGHER-ORDER CORRELATES OF GIFTED STUDENTS' MOTIVATION TOWARDS SCIENCE LEARNING

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Abstract

The purpose in this study is to examine possible higher-order factors (logical thinking and critical thinking) associated with gifted students' motivation towards science learning. Correlational research method was utilized and the study involved 70 gifted students (sixth, seventh and eighth grades). The data collection tools were Motivation towards Science Learning Questionnaire, Group Assessment of Logical Thinking Test and Critical Thinking Test. For the data analysis, Spearman correlation analysis was used. The results showed that motivation towards science learning of gifted students was significantly correlated by their critical thinking scores while there was no significant correlation between logical thinking and motivation towards science learning. However there was a significant correlation between logical thinking and critical thinking scores of gifted students. These findings show existence of a gap between motivation and logical thinking of gifted students in learning science.

Keywords: *Gifted students, motivation towards science learning, logical thinking, critical thinking*

Introduction

Science and scientific knowledge are necessary in today's world due to their contribution to making informed decisions. By understanding and using scientific knowledge lay people might turn the daily life comfortable and meaningful in terms of needs of human being. For example adjusting amount of salt and sugar when cooking or being aware of pressure needs of different foods are areas for using scientific knowledge. Among people, gifted individuals are taught to be effective in their daily life decision making; however they also represent a variety in terms of acquiring and using scientific knowledge in decision-making for daily life situation (VanTassel-Baska, Bass, Ries, Polan, & Avery, 1998). Students with high ability acquire and use effectively scientific knowledge, due to their characteristics they are always at the focus of science teaching and learning studies. In spite of this focus, regular science classes take learning needs of ordinary students into consideration hence learning of gifted students in science classrooms should be considered as a separate research problem. Generally learning science might be separated into three measurable domains in terms of types of learning; affective, cognitive and psycho-motor (Corallo, 1994; Rovai, Wighting, Baker & Grooms, 2009). Affective components (motivation, attitude, interest etc.) of learning are the basis for the other types of learning. Moreno and Mayer (2007, p. 310) stated that "*motivational factors mediate learning by increasing or decreasing cognitive engagement*". Schwinger, Steinmayr and Spinath (2009) studied the association between motivation and achievement. Their sample involved 231 11th and 12th grade German high-school students. Their findings showed that motivation was indirectly associated with achievement. Later Schwinger and Stiensmeier-Pelster (2012) tested a path model for explaining the association of motivation with achievements. The study involved 301 twelfth grade students and the path analysis found that motivational state of students is indirectly associated with achievement. This evidence is provided

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by domain-free perspective studies. In general studies on motivation do not treat motivation as a domain dependent factor (Eder, Elliot& Harmon-Jones, 2013; Kim, Park & Cozart, 2012; Rodriguez-Keyes, Schneider & Keenan, 2013). However the domain-free measures of motivation are not enough to explain associations of motivation towards science learning with higher-order variables such as critical thinking and creative thinking. By considering this problem, some studies used domain-dependent measurements and they involved measurement of motivation towards science learning in science domain (Loukomies *et al.*; 2013; Ng, Soon, & Fong; 2010; Tuan, Chin, & Sheh, 2005).

Motivation towards science learning is the most powerful determinant of quality regarding learning science (Fisher, 2000). According to Rumelhart and Norman (1978) motivation has more importance than cognitive variables in learning. Osborne, Simon and Collins (2003) also suggested giving more attention to motivation in science learning over the other affective factors in science learning. Motivation is a "*process which instigates and sustains a goal directed activity"* (Pintrich & Schunk, 2002). As in other affective factors, students also vary in their motivational status to learn science. Especially gifted students represented a special group of students in terms of studying motivation towards science learning. Since their use of deep learning strategies, increasing achievement, producing creative solutions to problems require being motivated towards science learning (Cho & Lin, 2011; Gottfried & Gottfried, 2004; Neber & Schommer-Aikins, 2002). However, the studies on motivation of gifted students also consider motivation as a domain-free affective factor. Cho and Lin (2011) investigated the relationship between creative problem solving and motivation of 733 scientifically talented Korean students (fourth-twelfth grades). The results showed that motivation levels of the participants towards learning were high and were associated significantly with their creative problem solving scores. In another study Vallerand, Gagné, Senécal and Pelletier (1994) investigated similarity between gifted (n=69) and ordinary (n=66) elementary students in terms of intrinsic motivation toward school activities. They found that gifted students' scores of intrinsic motivation were higher than those of ordinary students. Neber and Schommer-Aikins (2002) focused motivation in science domain and studied with 133 students involving gifted elementary and high school level students. The researchers showed existence of a strong correlation between the strategy use and the intrinsic value of science (r=0.63). Actually limited number of the studies focusing motivation of gifted students in science domain studied association between the motivation and the other affective self-report findings or perception scores on competency (Koksal, 2012; Koksal, 2013, Vallerand *et al.,* 1994). But the association between higher-order cognitive variables and motivation towards science learning remained open to investigate.

Among higher-order cognitive variables, critical thinking (Facione, 1986), creativity (Williams, 1999), logical thinking (Sendag & Odabası, 2009) and intelligence (Brown & French, 1979) are the most studied variables. Studies conducted by Garcia and Pintrich (1992), and Soerjaningsih (2001) showed that motivation is associated with critical thinking and logical thinking. Garcia and Pintrich (1992) studied on the association between critical thinking and motivation. Their study involved 758 college level students. The results showed a positive significant correlation between critical thinking and motivation. In Soerjaningsih (2001)'s study involving 422 university students showed that logical thinking and motivation were indirectly related to each other.

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Investigating higher-order correlates of motivation towards science learning might provide evidence for explaining association between high level of motivation towards learning science in gifted students and their higher-order cognitive abilities. Based on this idea, it is expected that learning science involving logical thinking and critical thinking requires high motivation towards learning science. Therefore there should be an association between motivation towards science learning and higher-order cognitive abilities. Hence, the purpose of this study is to investigate possible higher-order correlates (logical thinking and critical thinking) of gifted students' motivation towards science learning.

Method

In this study, correlational research method (Fraenkel & Wallen, 2006) was used since major purpose was to investigate relationships between motivation towards science learning and, critical thinking and logical thinking. In analysis of data, non-parametric Spearman correlation analysis was applied to the data since the motivation scores were non-normal and number of the participants was insufficient. As participants of the study, 70 gifted middle school students (sixth grade (n=22), seventh grade (n=35) and eighth grade (n=14)) were involved. Thirty nine of them were male while the remaining individuals (n=31) were female. The gifted students participating in the study were students of a public school but they were making project studies and taking courses from a center called Science and Art Center for gifted students. When they study in the center, the participants were taking courses on science and making laboratory studies in guidance of their mentor teachers. The data in this study were collected by four different data collection tools: Motivation towards science learning questionnaire, Group assessment of logical thinking test, Critical thinking ability test, and Wechsler intelligence scale (WISC-R).

Critical Thinking Ability Test

Development of critical thinking ability test was carried out by researcher for elementary level gifted and ordinary students. The test included 22 multiple-choice items and is composed of seven factors; *truth-seeking, ability of asking questions, analyticity, systematicity, self-confidence in reasoning, inquisitiveness and open-mindedness*. Reliability of the scores taken from the test was .77. The test was validated by applying it to 227 sixth, seventh and eighth grade students involving gifted and ordinary students. Confirmatory factor analysis results represented acceptable fit values (CFI=.95, GFI=.93, RMSEA=.03). Moreover the scores gifted and ordinary students on the test significantly differed in all components of the test.

Group Assessment of Logical Thinking Test (GALT)

For measuring logical thinking ability, *Group Assessment of Logical Thinking Test* (GALT) developed by Roadrangka, Yeany and Padilla (1982) was used. The test involved 21 items focusing 6 logical processes. These processes are summarized in six titles as mass, length, volume, conservation, proportional comparison, controlling the variables, consolidative comparison, probabilistic comparison and relational comparison. The alpha reliability of the test was found as

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0.71. The test was appropriate for 6th grade and above. Application of the test was completed in 45 minutes and Turkish version's reliability was .88 (Aksu, Berberoğlu and Paykoç, 1991).

WISC-R

WISC-R is the most frequently used intelligence scale in Turkey. It was developed by Weschler (1974) for determining gifted students. The scale is composed of two different parts; verbal and performance components. Savasır and Sahin (1995) carried out adaptation of the scale into Turkish and standardization of the scale for Turkish culture. The authors' sample for adaptation involved 1639 individuals from age 6 to age 16. They calculated split-half reliability and they found reliability as .97 for whole scale, .97 for verbal scale and .93 for performance scale. Also the correlation values between sub-component scores ranged from .51 to .86. The sub-components are composed of arithmetic, similarities, block design, picture completion, picture concept, matrix reasoning, vocabulary, comprehension, information, word reasoning, letter-number sequencing, coding, digit span, symbol search, cancellation (Öner, 1997).

Motivation towards Science Learning Questionnaire

The questionnaire was originally developed by Tuan, Chin and Sheh (2005). However adaptation of the questionnaire was done by the researcher. The content of the questionnaire were translated into Turkish by Yılmaz and Cavas (2007). The items taken from Yılmaz and Cavas (2007)'s translation were applied to the gifted students in this study. Due to the application of the items to a new group (gifted students, n=70) of study. Explanatory factor analysis was used after checking KMO and Barlett values for factorability of the scores (KMO=.82, Barlett Chi-Square=832.385, p<.00). The results supported factorability of the scores collected by the questionnaire (Sharma, 1996; Tavsancil, 2002). Results of the principle component analysis with varimax rotation supported four-factor solution (self-efficacy, setting performance goal, setting mastery goal and willingness to learn science) and reduced number of the items into 18 items. 18 items explained 75% of the variance. The reliabilities of the factors of the motivation questionnaire are represented in the table 1.

Table 1. Reliabilities of the factors of the motivation questionnaire

	Factors				
	Self-efficacy	Mastery goal	Performance goal	Willingness	Total
Cronbach Alfa	.94	.93	.79	.74	.92

Findings

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Before the examination of higher-order correlates of motivation towards science learning descriptive scores of the participants (n=70) were calculated. The findings on the descriptive scores are represented in the table 2.

Table 2. Descriptive values on the variables of the study

Variables	Mean	SD
Motivation	3.71	.73
Verbal IQ	136.84	8.71
Performance IQ	131.44	7.50
Total IQ	137.91	5.69
Logical Thinking	.51	.19
Critical Thinking	1.29	.37

As seen in table 2, levels of motivation towards science learning, critical thinking and logical thinking are higher than average scores for each variable. The mean scores for each variable are 2.5 for the motivation score, .5 for logical thinking and 1 for the critical thinking, respectively. Based on these scores correlational analysis (Spearman correlation) was done but before the analysis Boferroni adjustment (α=.01) was made due to multiple analyses. Findings on Spearman correlation analysis can be seen in Table 3.

Table 3. Spearman correlation coefficients between the variables of the study

First Variable	Second Set of Variables	Spearman Rho	*p*
Motivation towards science learning	Logical Thinking	.18	.15
	Critical Thinking	.31*	.01*

In table 3, it is seen that motivation towards science learning scores of the gifted elementary level students are significantly associated ($p<.01$) with critical thinking while there is no statistically significant relationship between logical thinking and motivation towards science learning scores ($p>.01$).

Discussion and Conclusion

The results of this study represented two important evidence; high motivation levels of gifted students to learn science and significant relationship between motivation towards science learning and critical thinking levels of the gifted students. Actually high levels of motivation towards science learning are expected in gifted students since science as a learning subject provides challenge and context for higher-order cognitive thinking (Taber, 2010). The findings are in line with the literature showing the gifted students' higher scores regarding motivation towards science

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learning, critical thinking and logical thinking than average scores. The literature on gifted students' motivational status to learn science (Koksal, 2013; Davis & Rimm, 1989) states that motivation level of gifted students are more than average level. When looked at the findings on critical thinking and logical thinking it was seen that critical thinking and logical thinking were used as criteria to be defined as gifted (Case, Demetriou, Platsidou & Kazi, 2001; Hiatt &Covington, 1991). Hence high levels of critical thinking and logical thinking are in line with expectations in this study.

Another important aspect of this study was correlational part of the study. Correlational findings of the study showed that there is a statistically significant correlation between motivation towards science learning and critical thinking scores. This refers to existence of a significant higher-order cognitive correlate (critical thinking) of motivation towards science learning scores of the gifted elementary students. This finding supported the literature showing an association between critical thinking and motivation. Garcia and Pintrich (1992) investigated association of critical thinking and motivation. They showed a significant positive correlation between critical thinking and motivation scores. However finding on the relationship between logical thinking and motivation is not in line with current literature, Soerjaningsih (2001) investigated association between logical thinking and motivation. The researcher showed that association between logical thinking and motivation were not direct. The differences in findings of the literature and this study might be related to sample size and school level differences in the studies. In this study, 70 elementary students were involved, this is a limitation. At the same time, the participants involved students enrolled in a science and art center; a gifted school after formal schooling time, this is another limitation for generalizing the findings.

In spite of the limitations, this study contributed to the literature since this study investigated motivation towards science learning rather than motivation toward learning. In other words motivation was measured as a domain dependent manner in this study. Another contribution involved evidence for a new group of students including gifted elementary level students. Previous studies focused on college or university level students. The findings of this study on the associations also showed a different picture that gifted students have higher scores of both motivation towards science learning and higher-order cognitive variables while the motivation is just related to critical thinking. This result means that the relationship between motivation and logical thinking might be related to existence of other possible mediators adjusting the relationship. Based on the strong and weak parts of this study, it can be suggested that number of the students should be increased and path analysis should be applied to the data taken from larger sample to investigate possible associations in following studies. At the same time moderator variables such as gender might also be tested in studying associations.

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