Comparison of Gifted and Advanced Students on Motivation Toward Science Learning and Attitude Toward Science

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Abstract

In this study, comparison of academically advanced science students and gifted students in terms of attitude toward science and motivation toward science learning is aimed. The survey method was used for the data collection by the help of two different instruments: "Attitude Toward Science" scale and "motivation toward science learning". Examination of reliability and validity of the scores on the instruments was conducted by using the "principle component analysis" with "varimax rotation" due to existence of a new group for validation of the instruments. The study involved 93 advanced science students and 12 gifted students who had higher IQ scores than 130 on WISC-R. The results of the study showed that the adapted instrument was valid and reliable to use for the measurements of motivation toward science learning in the context of advanced science classrooms. The comparisons of the groups in terms of the variables of the study showed that there is no statistically significant difference between the groups whereas there is significant difference between the groups in terms of the scores on the national examination.

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Learning about science and its products is a major requirement of our current age to make informed decisions, to overcome individual problems and to be competent in our job. In addition to learning science for daily life purposes, it is important to go further in developing scientific innovations to find new and more effective solutions of problems which are seen commonly in societies. Going further in science and scientific development is related to number of individuals who are more competent in understanding science and making science more effectively than ordinary individuals. One of the purposes of science education is to educate students who have higher ability in understanding science, knowing about scientific concepts and scientific products, and using science processes effectively. These students need special support and opportunities in learning science (Colangelo and Davis, 1997; Karnes and Bean, 2001). Formally, the opportunities on learning about science by high ability students begin formally at elementary grades and continue for a life-long time. High school years are very important period for learning about science content and science due to the fact that high school science courses are, unlike to the elementary level science courses, organized as separate scientific titles of disciplines such as biology, physics and chemistry. Separate titles are important for high ability (advanced) and gifted students since they need to think deeper on the science subject. At the same time, high school science courses taken by high ability students provide opportunities to see social aspects of science subjects as a challenging situation just before entering into the social life as a citizen.

Learning about science subjects and science in high schools by advanced and gifted students includes affective and cognitive factors which are determinants of learning quality and process. The cognitive factors involve the variables including information processing, reasoning ability and academic achievement (Köksal & Yel, 2007; Lawson, 2006; Lawson, Banks &Longvin, 2007; Schunk, 2000; Yumuşak, Sungur & Çakıroğlu, 2007) while the affective factors are composed of the variables such as attitude, self-efficacy, anxiety and motivation (Baldwin, Ebert-May & Burns, 1999; Ekici, 2005; Glynn & Koballa, 2006; Mallow, 2006; Osborne et al., 2003; Savran & Çakıroğlu, 2001; Uzuntiryaki & Çapa Aydın, 2008; Yumuşak et al., 2007). Among the affective factors, motivation toward learning science and attitude towards science have a separate place due to fact that both attitude and motivation are related to wide range of the variables that are important in science education (Wolters & Rosenthal, 2000; Tuan et al. 2005; Salta &Tzougraki, 2004; Wilson, 1983). Attitude toward science is the preparedness to think, feel, or react positively or negatively toward any object regarding to science (Petty, 1995). In a meta-analysis study focusing on attitudes toward science, it was shown that higher achieving girls, "doing well" or "achieving" in science were individuals "liking" more science than ordinary counterparts (Weinburgh, 1995). Salta and Tzougraki (2004) also stated that a positive attitude regarding to science course is more necessary for higher achieving students in maintaining their performance. For motivation factor, giving more importance to it in science learning over the other affective factors regarding to science learning is also suggested by science education researchers (Osborne et al., 2003). Motivation is defined as the process which instigates and sustains a goal directed activity (Pintrich & Schunk, 2002). There are many studies in which relationship of motivation with educationally important outcomes are presented. Motivation is correlated to the scores on science attitude and achievement (Tuan et al. 2005). Again, existence of more effort and perseverance of students with higher motivation are also correlated with motivation (Wolters & Rosenthal, 2000). In another research, Palmer (2005) stated that motivation plays an important role in construction of knowledge and conceptual change. Moreover, Pintrich & DeGroot (1990) focused on higher-order cognitive variables and they showed that there was a significant relationship between motivational factors and cognitive constructs such as strategy use and meta-cognition. In Turkish context, Köksal & Tasdelen (2007) also showed relationship of motivational factors including self-efficacy and task value with use of rehearsal and organization in learning science. In addition to the correlation studies, Glyn & Koballa (2006) presented that science motivation predicts interest in science, number of courses taken and science grades. Correlations of motivational factors regarding to science learning and attitude toward science with both other affective factors and cognitive variables provide a significant place to study motivational and attitudinal situations of advanced and gifted students toward science learning.

The advanced and gifted students are different from their ordinary counterparts in terms of motivational characteristics. Gottfried and Gottfried (1996) pointed out, by studying on the students at the age range from 9 to 13, that advanced students had significantly higher academic intrinsic motivation across all subject areas including science and school in general. Again, Vallerand, Gagne, Senecal and Pelletier (1994) focused on lower grades involving 4. 5. and 6. grade students and they found that advanced students felt themselves as more competent and intrinsically motivated toward activities in school than traditional students. The attitude toward science is another characteristic by which gifted students differentiate from ordinary students.

The gifted students present more positive attitudes toward science than their ordinary counterparts (Caleon and Subramaniam, 2008). In another study (Harty and Beall, 1984), it was shown that gifted students hold more positive attitudes towards science than nongifted students. Talib, Luan, Azhar and Abdullah (2009) also showed that advanced science students, similar to gifted students had also high positive attitudes toward science. In the literature presented above, the studies on the motivational and attitudinal characteristics of gifted and advanced students with regard to science did not try to compare advanced and gifted students in terms of motivation toward learning science and attitude toward science while they compared gifted or advanced students with ordinary students. But these groups of the students; gifted and advanced students, are also different from each other in terms of diagnostic ways. Gifted students are determined by applying IQ tests, other standardized ability or special field tests whereas advanced students, not taking any IQ test, have higher motivational (high motivation toward learning science), cognitive (high achievement in science) and affective (high positive attitude toward science) characteristics regarding to a special field such as science than their ordinary counterparts (Brown, Renzulli, Gubbins, Siegle, Zhang and Chen, 2005; Koksal & Sormunen, 2011). Both of these groups of students need special attention in designing a science course due to their difference from ordinary students. Because gifted students carry the characteristics of "asking challenging questions", "being impatient with the pace of other students", "having perfectionist traits", "disliking routine and busy work", "being critical of others" and "being aware of being different" into science classrooms (Park and Oliver, 2009) while advanced science students have high motivation toward learning science, positive attitude toward science and higher scores on science content tests (Koksal & Sormunen, 2009).

Therefore, it was thought that comparison of advanced science students and gifted students in terms of attitude towards science and motivation toward learning science might provide an important point for making motivationally and affectively effective instructional science course designing the programs including gifted and advanced students.

Method

For the purpose of this study, cross-sectional survey method was utilized by using two instruments: "motivation toward science learning" questionnaire and "attitude toward science" scale. The instruments were applied by classroom teachers. The participants were selected purposively for considering advanced science students' enrollment in science high schools, motivation and attitude scores and by reaching gifted students in science and art center of a middle scale city in Turkey.

Participants

The number of all participants is 105 9th grade students at the age f 15. Ninety three of them (47 female, 46 male) are advanced science students while 12 gifted students (7 female, 5 male) are included in the sample. The advanced science students are enrolled in science high schools where they are taking more courses on science and denser science content than ordinary high schools and they are also selected to this school by taking highest scores in a nation-wide content test. The advanced students are in top % 5 of the all test takers (over 800.000). the gifted students are enrolled in Science and Art Center of a middle scale city of Turkey. The gifted students are selected to the center based on their IQ test scores on WISC-R. The students involved in this

study have IQ scores over 130. In the center they are taught the science subjects by making mentorship and they are included in small groups during the teaching. They have also opportunity of making lab applications with their teachers and of making independent research. All of the activities of the center are made as out-of-school applications.

Instruments

The 'Motivation toward Learning Science' questionnaire (MLSQ) developed by Tuan, Chin and Sheh (2005), the 'National Examination' results and 'Attitude toward Science' scale (ATSS) developed by Geban, Ertepınar, Yılmaz, Atlan and Şahpaz (1994) were used as data collection tools in this study. The questionnaire and scale were applied to all of 105 participants, to gather reliability and validity evidence on the sample of 9th grade advanced and gifted students. The items of MLSQ were translated into Turkish by Yılmaz and Cavas (2007) and the researchers adapted the instrument for ordinary elementary students. The ATSS was also developed for ordinary students by Geban, Ertepınar, Yılmaz, Atlan and Şahpaz (1994). Due to the difference of the participants in this study from elementary ordinary students, reliability and validity studies were done by using principle component analysis and calculation of Cronbach alpha coefficient.

Reliability and Validity of Scores on the ATSS

Before the running principle component analysis, KMO (Kaiser-Meyer-Olkin) value and Barlett's Sphericity Test results were investigated to test whether the Data werefactorable or not (Büyüköztürk, 2002). The results showed that KMO value and the Barlett's test results are appropriate to go on making further analysis with the data (KMO=.90, Barlett's Test Chi-Square=551.34, df=78, p<.05). The results of principle component analysis with varimax rotation presented that 14. and 7. items of the original instrument were not appropriate due to their loadings on two different factors with high factor loadings. The remained items (n=13) loaded on two factors and explained 55% of the total variance in attitude toward science. One example of the items is "I experience pleasure when I come to science course". In table 1, Cronbach Alpha values and descriptives for the scale are presented.

Table 1. Cronbach Alpha values and descriptives for the scale (n=105)

Instrument	Number of Items	Number of Factors	Names of Factors	Cronbach Alpha	Explained Variance
ATSS	13	2	Attitudes regarding to general and personal contributions of science and importance of science in daily life	.90	%44
			Attitudes toward format of the science content and negative attitudes toward science course	.89	%11
					55 %

Table 2. Factor Loadings of The Factors of the ATSS

Factor Loadings of The Factors of the ATSS		
Items	**Factors**	
	1	**2**
Item 6		**,792**
Item 12		**,763**
Item 4		**,738**
Item 13		**,731**
Item 1		**,596**
Item 9		**,588**
Item 10	**,729**	
Item 11	**,657**	
Item 3	**,655**	
Item 15	**,630**	
Item 2	**,616**	
Item 5	**,615**	
Item 8	**,553**	

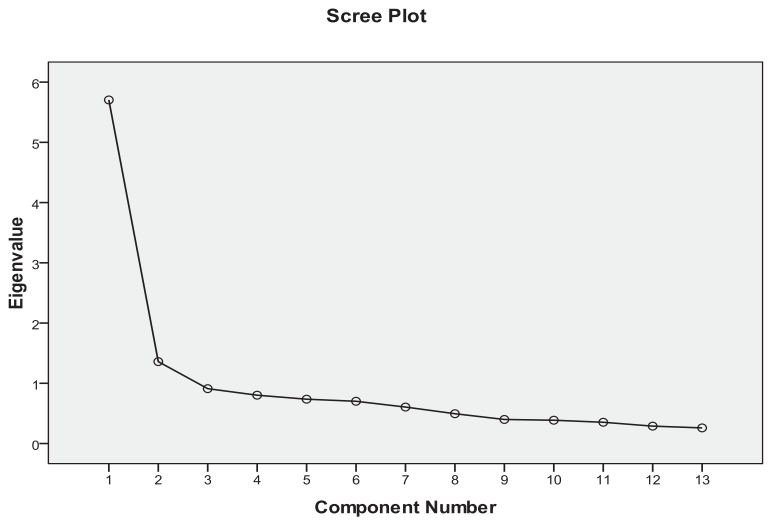

Figure 1. Screen Plot Graphic of the scores on the ATSS

As seen in the figure 1, the scores of the participants on the ATSS were loaded on two different factors. Screen plot graphic becomes smooth after the third point, there are two points showing the number of the factors above this level.

Reliability and Validity of Scores on the MLSQ

Similar process with ATSS scores was also applied to the scores of MLSQ. Before the principle component analysis, KMO (Kaiser-Meyer-Olkin) value and Barlett's Sphericity Test results were checked to see whether the Data were factorable or not (Büyüköztürk, 2002). The results showed that KMO value and the Barlett's test results are appropriate to go on making further analysis with the data (KMO=.93, Barlett's Test Chi-Square=3706,65, df=465, p<.05). The results of principle component analysis with varimax rotation presented that 23. and 32. items of the original instrument were not appropriate since they load on two different factors with high factor loadings. The remained items (n=31) loaded on four factors and explained %76 of the total variance in attitude toward science. One example of the items is "I am sure I will be successful in science exams". In table 3, Cronbach Alpha values and descriptives for the questionnaire are presented.

Table 3. Cronbach Alpha values and descriptives for the questionnaire (n=105)

Instrument	Number of ɛms	Number of ıctors	Names of Factors	Cronbach Alpha		Explained Variance	
MLSQ	**31**	**4**	Motivation toward the ways used in science learning	**.98**	**.98**	**%61**	**%76**
			Motivation regarding to personal tasks in science learning	**.87**		**%6**	
			Teacher-related motivation	**.75**		**%6**	
			Extrinsic Motivation	**.76**		**%3**	

Table 4. Factor Loadings of The Factors of the MLSQ

Factor Loadings of The Factors of the MLSQ				
Items	**Factors**			
	1	**2**	**3**	**4**
Item 24	**,884**			
Item 25	**,866**			
Item 26	**,859**			
Item 8	**,847**			
Item 27	**,819**			
Item 11	**,814**			
Item 13	**,805**			
Item 14	**,771**			
Item 10	**,763**			
Item 7	**,760**			
Item 19	**,746**			
Item 4	**,739**			
Item 12	**,717**			
Item 17	**,710**			
Item 9	**,709**			
Item 16	**,690**			
Item 15	**,661**			
Item 18	**,639**			
Item 6	**,596**			
Item 28	**,567**			
Item 33	**,565**			
Item 2		**,841**		
Item 1		**,792**		
Item 3		**,668**		
Item 5		**,619**		
Item 31			**,837**	
Item 30			**,821**	
Item 29			**,515**	
Item 20				**,804**
Item 22				**,769**
Item 21				**,617**

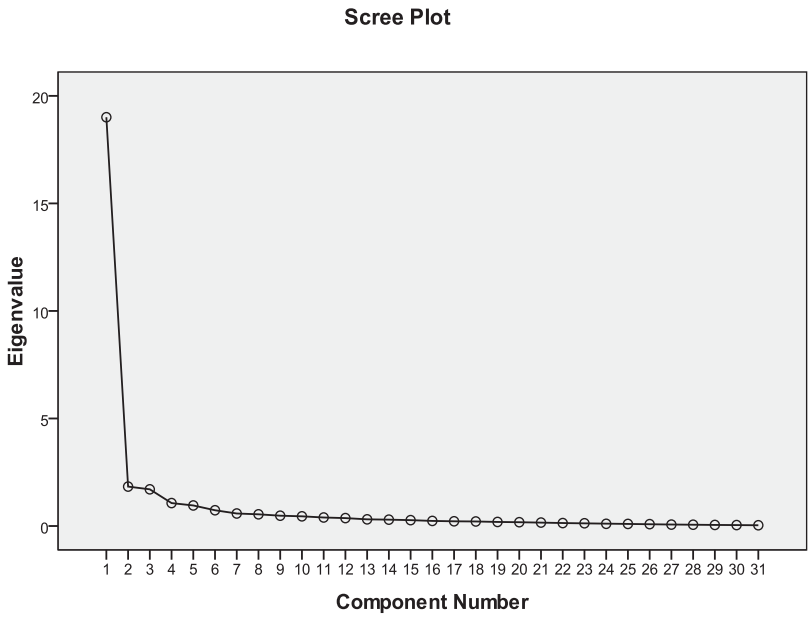

Figure 2. Screen Plot Graphic of the scores on MLSQ

As seen in the figure 2, the scores of the participants on the MLSQ were loaded on four different factors. Screen plot graphic becomes smooth after the fifth point, there are four points showing the number of the factors above this level.

Analysis of the Data

The analysis of the Data was conducted by Mann-Whitney U tests for the purpose of comparing two groups in terms of motivation toward science learning" and "attitude toward science". The reasons of choosing Mann-Whitney U Test are non-normal data distribution and unequal numbers of the participants in the groups (Green, Salkind & Akey, 2000). The normality test was performed by calculating Skewness and Kurtosis values and it was found that the data is not normal. For comparing the groups, two different applications of Mann-Whitney U test were done, so Benforroni adjustment was made to hold type I error rate (.05) constant. The calculated alpha value was set as .025 for each test. Table 5 represents descriptive values of the scores on the instruments.

Table 5. *Descriptive Statistics for the variables of the study*

Variables (n=105)	**Mean**	**SD**	**Skewness**	**Kurtosis**
Total				
Attitude Toward Science	4,04	,63	1,01	1,81
Motivation Toward Science Learning	3,54	1,09	1,20	3,55
National Examination Scores	469,49	11,88	,45	,82
Descriptives of Gifted Sample Scores (n=12)				
Attitude Toward Science	3.96	.76	1.01	.07

Motivation Toward Science Learning	3.7	.68	1.9	4.2
National Examination Scores	489.36	4	.01	.65
Descriptives of Advanced Sample Scores (n=93)				
Attitude Toward Science	4.04	.61	.99	2.14
Motivation Toward Science Learning	3.54	1.14	1.9	3.20
National Examination Scores	467.14	10.18	.52	.47

Results

The groups in this study were compared to validate difference between them in terms of cognitive variables. The first evidence of the difference comes from the IQ scores of the participants. The students in the sample are coming from the same population, but their IQ scores differentiate them as the scorers below 130 and scorers above 130. For gathering the second evidence for the difference, their OKS scores were compared. The results of the comparison can be seen in table 6.

After the validation of the difference between the groups of this study, comparisons of the groups in terms of dependent variables were done. The data analysis regarding to the descriptive statistics showed both of the groups had higher mean attitude (over 3.9/5) and motivation scores (over 3.5/5) with related to science and science learning. After investigation of the descriptives, the data gathered from the participants were compared across the groups by the inferential statistics. The analysis results on the comparisons can be seen in table 6.

Table 6. Analyses Results on The Comparison of the Groups in terms of the Dependent variables

Variables (n=105)	**Group**	**Mean Rank**	**U**	***p***
National Examination Scores	Gifted	96,45	28,00	,00*
	Advanced	47,30		
Motivation Toward Science Learning	Gifted	53.04	557,50	,99
	Advanced	52,99		
Attitude Toward Science	Gifted	52,25	549,00	,93
	Advanced	53,10		

Note: *p<.025

The scores on the national examination differed significantly (p<.025) across the groups in favor of the gifted students. Gifted students had significantly higher scores than their advanced counterparts. However, the results of the study showed that the scores of the groups were not statistically different from each other in terms of “attitude toward science” and “motivation toward science learning”.

Discussion and Suggestions

The results of this study provide significant understandings for the difference between 15 aged gifted and advanced science students in terms of motivation towards science learning and attitude toward science. Before discussion of the motivation and attitude, it is important to say that the gifted group and advanced group are significantly different from each other in their scores on national examination and IQ. The gifted group has significantly higher scores than their advanced counterparts. The national examination scores are based on science content knowledge and effective mental ability use on purposes of the examination in which making comparisons, analyzing tables, making mathematical calculations, drawing conclusions and findings patterns. The higher scores of the gifted students on the national examination are related to their better performance and higher ability on mental tasks than advanced science students (Arffa, Lovell, Podell, Goldberg, 1998; Seidenberg, Giordani, Berent & Boll, 1983). And another reason for the difference in the national examination scores is about their selection of the programs based on their IQ scores focusing on mental functions or cognitive side of the learning. Therefore, the differences between the groups in terms of IQ and national examination scores can be used for validation of the group difference in terms of cognitive or mental abilities.

After the investigation of the cognitive difference between the groups, the main variables of this study were investigated. The results showed that the gifted and advanced science students have high scores on the attitude and motivation. As a supporting study, Tang and Neber (2008) also found that gifted students had high motivation scores over 4.5/5 with regard to chemistry learning. In another supporting study, Caleon and Subramaniam (2008) showed that advanced and gifted students had highly positive attitude scores over 22/30 with regard to science. The results showed no difference between the groups in terms of the dependent variables of the study. It indicates that although the gifted and advanced science students are different in terms of cognitive abilities, they are similar to each other in terms of motivation toward science learning and attitude toward science. The findings of this study supported the previous studies. Caleon and Subramaniam (2008) found that there was no difference between advanced and gifted students in terms of attitude toward science. This similarity might be related to experiencing the similar science education activities, to meeting similar science teachers and to be evaluated on science learning in similar ways. The gifted and advanced science students are enrolled in the same schools (Science High Schools). Only one difference lies in taking courses from "Science and Art Centers" where only gifted students take courses after their formal school time. Similarity in the experiences of the gifted and advanced science students makes contribution to the similarity or nondifference between them in terms of the attitude toward science and motivation toward science learning.

This result is important due to the fact that the gifted teaching programs should consider school factors including non-gifted students who are partners and friends of gifted students in Science High Schools. If the students having similar affective readiness to begin a cognitive task are involved in a gifted education program, it might be more effective to provide opportunity of improving mental abilities of advanced science students by modeling their gifted counterparts while the gifted students have opportunity of making social relationships with the friends who are not different as far as ordinary students. The results of this study drive us to consider positive dual effects of the similarity between gifted and advanced science students in terms of

motivation toward science learning and attitude toward science in gifted education programs regarding to science.

Based on the findings of this study, it can be suggested that the similarity between the gifted and advanced students in terms of affective and motivational factors regarding to science and science learning respectively should be taken into account in assessment and selection activities for a gifted science education program. In spite of the evidence of the difference between the groups in terms of national examination scores and IQ, there is a need to compare the groups who have more number of members, to increase validity of the difference in mental abilities. At the same time, more number of the participants should also be reached to increase power of the statistical technique (using parametric statistics). This study is limited to ninth grade students and it includes only results on the scores of all the participants, but gender difference and difference between various IQ groups should be investigated with more participants.

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