

On the Role of Learning Styles Components (Objective Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation) on Students' Mathematics Performance

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Abstract The present study tries to explore the effect of learning styles on the mathematical performance of secondary school students. In addition to environmental and individual variables, learning styles are also influenced by culture and gender. To this end, a descriptive correlational procedure was followed. The sample consisted of 300 individuals, half being males and half females. Cluster sampling was utilized as a part of this investigation. To assess the learning styles of the students, Kolb's learning style questionnaire [19] was utilized. In this study, we utilized the first semester grades of the students in the academic year 2012-2013 in mathematics to gauge their mathematical performance. Descriptive statistics including was used to analyze the data, expressive measurements strategy including standard deviation, frequency calculation, chart, average, and inferential statistics methods including Pearson's correlation coefficient, ANOVA, regression analysis, and post hoc tests were utilized. As the results showed, students' performance was significantly predicted by concrete experience and abstract conceptualization significantly predicted the performance of students in mathematics. A significant difference was also observed between boys and girls in reflective observation and active experimentation learning methods. These results can have applicable implications in school consultations and be used in designing appropriate strategies by considering gender and learning styles.

Keywords: *learning styles, performance in mathematics, concrete experience, reflective observation, abstract conceptualization, active experimentation*

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1. Introduction

Mathematics as a scientific subject is an inseparable part of curriculums in all societies from elementary to university degrees. Mathematics is also one of the most prominent measures of educational progress to gain a suitable position in higher education for students. As a matter of fact, mathematics is an indicative filter in front of students who seek to professionally follow a career in the technical and scientific fields (Pagars & Graham, quoted from Brockman [11]).

Concerning the importance of mathematics, we can say that mathematics is one of the most important majors in the contemporary developing world. Societies which are

aware of mathematics and teach mathematics to the new generation based on thinking and reasoning skills will be a pioneer in all fields in the future. This is the very goal toward which all researches and, particularly, teaching mathematics are targeted. Reflecting the results of the studies in the process of education is not an easy task, because educational processes are influenced by various factors such as teachers and students which are the most important components of this process [13].

In 1972, the common definition for mathematics anxiety was presented by Richardson and Suin as follows: feelings indicating tension and stress which intervene the wide spectrum of educational opportunities and daily life by manipulating numbers and solving mathematical problems (cited from web, 2008).

Lazarus (1974, quoted from Bon Stetter, 2007) defined mathematical stress as a kind of math phobia which is an irrational and impeding fear of mathematics. This fear of mathematics has created mental and emotional impediments which makes future progress in mathematics really hard. Thus students choose a fatalistic attitude and expect to have a poor performance in mathematics. These conditions lead to a faulty cycle and a prosperous prediction.

In another definition, mathematics stress is defined as a sense of failure about the ability of performing mathematical operations. Students may experience this anxiety in various levels in such a way that even attending mathematics classes can cause stress for some.

This anxiety can even be experienced by those students who are studying mathematics at home (Mathematics and reading help, 2003).

Parry (2004, quoted from Fuson, 2007) has defined this anxiety as the inability of a person in dealing with quantitative situations and, more generally, mathematics.

Ashcraft and Faust (1994, Quoted from T. Jessi, 2002) have defined mathematics anxiety as a sense of tension, helplessness, mental disorganization, and personal fear when it is necessary to manipulate numbers, draw pictures, and solve mathematical problems.

Another particular feature of mathematical stress is that it can be described as a sense of uncertainty and helplessness in dealing with dangers (May, 1971; quoted from T. Jessi, 2002).

Various categorizations have been proposed about the reasons of mathematical stress. Some believe that mathematical anxiety is the result of the interaction among various factors including the mathematics itself, education issues and curriculum, parents' attitude, values and expectations of mathematics (Lazarus, 1974; Quoted from Bal Oghlu, 2002). Some like Shodahl & Diers (1984, quoted from Bal Oghlu, 2002) concluded that some of the causes of mathematical anxiety include unpreparedness of students, attitudes of teachers and their methods, insufficient books and students' thinking level. In this respect, Berbitsk (1985, quoted from Bal Oghlu, 2002) in his review of the related literature on mathematical anxiety between 1954 to 1985 stated that parents' attitudes, teachers, and the nature of mathematics are important factors which could be cited in mathematical anxiety.

1.1. Learning Styles

One of the characteristics of people which is an important and effective factor in the process of learning and its associated contexts is their learning styles. Learning styles is defined as the way people think or view the world. Learning styles represent information processing methods against various stimuli, while people in various situations process the information based on their environmental conditions. Yet, they have an integrated and particular totality and this totality has stable and durable features. People act uniquely based on these stable attributes. This performance, dealing with environment and learning opportunities is a function of learning styles, and learning styles are a function of stable and durable attributes [4].

There are 4 learning styles which are different from one person to another:

1- Divergent learning style: people with this style view concrete opportunities from different angles. Their attitude to a situation is more of watching than performing.

2- Absorbent learning style: people with this learning style have great opportunities in acquiring and understanding huge information and combining them in a precise manner.

3- Convergent learning style: people with this learning style have the greatest efficiency in scientifically applying theories and thoughts and have a better performance in solving the problems and planning structures.

4- Accommodating learning style: these people enjoy first hand and instructive experiences and challenging works. They are quite capable in performing works and immediate planning and accommodation with new condition [6].

Style is a method for learning, identification and thinking. Style is not equal to comprehensive ability, it is a method through which the capabilities are utilized. As individual capabilities are very important for success in life, identifying learning styles is also important. In other words, learning styles are individual preferences, not capabilities (Kolb, 1984; quoted from Bazr Afshan, 2009).

As people have various learning styles and these methods influence their educational progress, teachers and instructors should also be fully familiar with all styles so that they can guide students to better leaning [5]. Teachers' ignorance of individual differences in learning and education leads to the learners' failure in acquiring information, the capabilities and skills required for literacy, failure in education and job and even unpreparedness for becoming a good citizen. This ignorance of individual differences especially in the field of learning styles has created a constant educational environment, fixed times for starting and ending classes, and a fixed length for educational periods. As a result, those learners whose educational opportunities are not suitable for their learning style will not have the facilities required for gaining information and success in education. They will not make enough progress and are removed from the educational system in some cases [8].

Studies have indicated the existence of a positive and significant relationship between students' leaning style and their educational progress [9,10,20].

Choosing similar education methods as an external factor can have a suitable performance in forming the mathematical behavior of students. As the developing and dynamic mathematical behavior is the result of the efficient interaction between external and internal factors, thus teaching the mathematical concepts and skills regardless of the internal factors, especially individual differences like the learning style of the students, is non-scientific and will never yield the desired effectiveness in learning mathematics. In the meantime, mathematics teachers and instructors' attitude towards students' learning style is of great significance so that students can be in a better condition for participation and learning by selecting the appropriate learning method and class activities. Doubtlessly, teachers' scientific authority and their educational method in teaching and conducting mathematical activities will result in the better performance of people in mathematics [3].

By knowing about their students' learning methods which yields a deeper understanding in them, teachers can

facilitate teaching and preparing lesson materials. Also, informing the students of their learning style and their strengths and weaknesses helps them realize why it is sometimes hard for them to learn. Students can be aided for coordinating their learning style with their teacher's teaching method. Preparing lesson materials in accordance to their preferred method for learning can facilitate their learning [14].

1.2. The Role of Gender in Learning Style

We will also investigate the gender differences in learning methods and the results of different studies are different in this field. The hypothesis of the socialization of gender role admits that women have greater mathematical anxiety due to having less experience with mathematics (Hunsley & Flessati; quoted from Bal Oghlu, 2002). Historically, mathematics has always been viewed as a masculine field, although women have also made great contribution to formation and development of the main hypothesis in mathematics. In this field, traditional social influences have had a great influence in causing the current imbalance between men and women in their tendency towards learning and performance in mathematics. Women have always been known as to have greater mathematical stress or avoid mathematics (Bon Stetter, 2007). Tobiaz (1993, quoted from Formd and Borman, 2008) acknowledged that the differences between men and women in terms of their mathematical experience cannot be attributed to their instinct. As a matter of fact, the results of a study conducted by Schodfield (1982, quoted from Bon Stetter, 2007) on 1896 elementary students of grades 3 to 5 in Australia indicated a significantly stronger relationship between attitude towards mathematics and educational progress among boys in all three levels.

Hmbari (1990, quoted from Bon Stetter, 2007) realized that although women report greater mathematical stress than men, their mathematical performance in the middle grades of school is much better than their male peers. On the other hand, there is a great gap between male and female students of high school degree in terms of their scores in mathematics in scholastic aptitude test. Compatibly, male students have been nearly 50 scores above their female peers.

The gender gap in mathematics in early childhood and elementary school is not too visible. But in some educational stages in the middle courses before high school, female students start to believe that successful study of mathematics is beyond their capability (Liyahi & Give, 2001; all the above-mentioned issues are quoted from Bon Stetter). Hyde, Zema and Lemon (1990, quoted from Fuson, 2007) stated that gender differences influence progress in mathematics, especially when students go to higher grades of education and college. Hyde et al did not find any significant difference in educational development in mathematics among the 2 genders in the first highschool level, yet a growing progress trend was witnessed in the performance of men compared to women in the second highschool course and college. Sax (1994, quoted from Fuson, 2007) suggested that women's progress in mathematics is greatly dependent upon their self confidence and grandstanding in mathematical situations. Kaprimo (1990, quoted from Fuson, 2007)

suggested that women's lack of confidence in their capabilities is due to the fact that they are taught they are not as capable as men in the field of mathematics. Greshaw (1996, quoted from Routi, 2008) showed that 33% of girls (compared to 10% of boys) report they have never been encouraged by their teachers to pursue and meditate on mathematical problems.

Thus, in this research we will seek to investigate whether students' learning styles (with the components of concrete experience learning, reflective observation, abstract conceptualization, and active experimentation) can predict their performance in mathematics or not. We will also seek to see if there is a difference between the learning style of the guys and girls (with components of concrete experience learning, reflective observation, abstract conceptualization, and active experimentation).

2. Research Tools and Methodology

The present research is a correlational study which can be categorized as a descriptive plan where the researcher merely studies the synchronic and predictive relationships between variables, without manipulating them. The statistical society of this research included all the male and female students of grades one, two and three of governmental and non-governmental highschools (human sciences) of Damghan in the educational year 2012-2013. According to the Department of Education of Damghan the statistical society included some 1116 students from whom 300 students (150 males and 150 females) were selected based on a random clustering pattern.

To measure the learning styles, the tool used in this research was Kelb's learning style inventory [19]. The early version of Kelb's questionnaire consisted of 4 self-descriptive questions. However, in 1985 he upgraded his questionnaire to 12 self-descriptive questions which consisted of 4 sections and each section measures a part of the abilities. Each question consists of four parts and the subject must answer them in 15 minutes. As the subject reads through the questions, he will give 4 to the part which corresponds the most to his learning style. So the value of each question is specified by 1, 2, 3, and 4. Different parts of this test include concrete experience, reflective observation, abstract conceptualization, and active experimentation. As we add the score of these four parts, 4 score will be derived which represent the 4 learning methods. By the binary subtraction of these scores (subtracting abstract conceptualization from concrete experience and subtracting active experimentation from reflective observation) 2 scores will yield. These 2 scores will be placed on the coordinate axis, i.e. the vertical axis (abstract conceptualization-concrete experience) and horizontal axis (active experimentation-reflective observation). The coordinate axis form the 4 quarters of a circle which correspond to the four learning styles of divergent, convergent, absorbent, and accommodating learning styles [19].

Rahmani shams [4] used Cronbach's alpha to measure the validity of this method. These coefficients are arrayed in Table 1.

As it is seen, the resulting Cronbach's alpha for the 4 main components of the learning styles questionnaire is in a high and desirable state. Reflective observation, concrete

experience, active experimentation, and conceptualization respectively have the highest to the lowest validity coefficient.

Table 1. The coefficients resulting from Cronbach's alpha about the validity of learning style questionnaire

learning method	Cronbach's alpha coefficient
concrete experience	(0.73)
reflective observation	(0.80)
abstract conceptualization	(0.65)
active experimentation	(0.71)

Kelb [19] also used Cronbach's alpha method to measure the validity of all 4 styles and these coefficients are presented in Table 2.

Table 2. The resulting coefficients of applying Cronbach's alpha about the validity of learning style questionnaire

learning method	Cronbach's alpha coefficient
concrete experience	(0.78)
reflective observation	(0.83)
abstract conceptualization	(0.73)
active experimentation	(0.82)

As it is seen according to Kelb's study, the coefficient of Cronbach's alpha validity for the four main components of learning style questionnaire shows that the validity coefficients of the four components are in a desirable state. Content validity of this test was studied in the latest research conducted by Willcoxson. This indicates an appropriate validity and is quite suitable for measuring styles [7]. Due to having great correlations with similar scales such as MirzBrigz's personality evaluation indicator, this tool has a great validity [4].

In this research, the math marks of the second semester of the students in the educational year 2012-2013 was collected to measure the variable of mathematical performance.

2.1. Data Collection Method

To collect data, the 2 above-mentioned questionnaires were answered by the students in the form of groups. The respondents were first briefed about each one of the questionnaires so that they can have a general knowledge about the questionnaires. Then learning style and mathematical anxiety questionnaires were distributed among the students and they were asked to answer the questions.

2.2. Data Analysis Method

To analyze the data, descriptive statistics method including frequency calculation, chart, average, standard deviation, and inferential statistics methods including Pearson's correlation coefficient and regression analysis and variance analysis method and post hoc tests were utilized.

3. Results

To study the relationship between the students' learning methods (with components such as concrete experience, reflective, observation, abstract conceptualization, active experimentation) and their performance in mathematics, regression analysis was utilized after correlation matrix. The results are presented in Table 3 and Table 4.

Table 3.

	math marks	concrete experience	reflective observation	abstract conceptualization	active experimentation
math marks	1				
concrete experience	0.050	1			
reflective observation	0.15**	0.14*	1		
abstract conceptualization	0.21**	0.30**	0.38**	1	
active experimentation	0.10	0.11*	0.83**	0.37**	1

** significant in the level $P < 0.01$

* significant in the level $P < 0.05$

As it is seen in the table, the 2 components of reflective observation ($r=0.15$) and abstract conceptualization

($r=0.21$) are associated with performance in mathematics and their correlation is significant in the level of 0.01.

Table 4. Mathematics performance prediction model based on learning methods

variables	R	R2	moderated R2	ascites F	level of significance
abstract conceptualization	0.213	0.045	0.042	14.147	0.0005
abstract conceptualization	0.244	0.060	0.053	9.403	0.0005

As you can see in Table 4, abstract conceptualization has entered the regression in the first stage and has determined 4.5% of the standard variation in mathematical performance. In the second stage, concrete experience as

another variable of learning methods has entered regression and both variables (abstract conceptualization and concrete experience) could determine 6% of the variance in mathematical performance.

Table 5. Step by step regression analysis coefficients for predicting the mathematical performance based on the learning methods in the last step

variables	non-standardized coefficients		standardized coefficients	t	level of significance
	B	Standard error	Beta		
constant	8.284	1.733	-	4.779	0.0005
abstract conceptualization	0.204	0.048	0.2510	4.246	0.0005
concrete experience	-0.091	0.043	-0.125	-2.120	0/0350

Based on this table, among various learning methods, abstract conceptualization and concrete experience significantly predict the performance of the students. In the final model, the value of standardized regression coefficient for abstract conceptualization equals 0.251 and the very same coefficient equals -0.125 for concrete experience. Based on the value of the ascites calculated

for t for each variable which is significant in the alpha level of 0.05, we will conclude that these variables are significant in predicting the performance of the students. To investigate the existence of any differences among girls and guys in learning methods, multi-variable variance is used whose results are presented in the table below.

Table 6. The descriptive ascites of the marks concerning learning methods in terms of the genders

variables	gender	number	average	standard deviation
concrete experience	female	150	30.41	6.89
	male	150	29.38	6.076
reflective observation	female	150	36.54	5.19
	male	150	34.24	5.35
abstract conceptualization	female	150	33.51	5.60
	male	150	32.33	6.040
active experimentation	female	150	36.26	5.88
	male	150	34.42	6.60

To study the differences of learning methods in terms of gender, multivariable variance analysis test was utilized. The analysis results showed that a significant relationship exists between the learning methods linear combination

average and gender (Wilks Lambda= 0.94, F=4.074, P<0.05). It means that girls have gained higher marks than boys. To investigate the difference patterns, variance analysis test was utilized as follows.

Table 7. Inter-test influences test in relation to learning method differences considering gender variable

variables	source	sum of squares	degree of freedom	average of squares	ascites F	level of significance	size of the influence
concrete experience	intergroup	80.08	1	80.08	1.898	0.169	-
	intragroup	12575.71	298	42.200			
reflective observation	intergroup	399.05	1	399.05	14.316	0.0005	0.046
	intragroup	8306.53	298	27.87			
abstract conceptualization	intergroup	104.43	1	104.43	3.075	0.081	-
	intragroup	1012.80	298	33.96			
active experimentation	intergroup	252.08	1	252.08	6.437	0.012	0.021
	intragroup	11669.55	298	39.16			

This table shows the following information for concrete experience: (F=1.898 & P>0.05). Thus, no significant difference is observed between the average of the marks of girls and boys in this variable. Abstract conceptualization variable (F=3.075 & P>0.05) also yielded the same results. However, reflective observation (F=14.316 & P<0.001) and active experimentation (F=6.437 & P<0.05) also showed a significant difference between the average of girls and boys.

4. Discussion and Conclusion

According to the results of the discussion, among various learning styles, abstract conceptualization and concrete experience can significantly predict the performance of the students in mathematics. The value of the standardized regression coefficient for abstract conceptualization was 0.251 and the very same value for concrete experience was -0.125. Based on the value of t ascites yielded for each variable which is significant in the alpha level of 0.05, we will conclude that these variables influence the performance of the students in mathematics. These results are in accordance with the studies of Coker [12] and Barary [1]. These researcher proved that a significant relationship exists between learning methods and educational progress. In an effort to reach useful educational results, we can there is nothing as important as

the importance of students' various learning methods and the necessity of teachers' familiarity with these styles in all classes. Gaining information about the learning methods of the students can make great contribution to their learning. By knowing their students' learning styles which results in deeper understanding among them, teachers can facilitate their teaching efforts and preparation of lesson materials. Informing the students of their styles and points of strength and weakness can help them realize why it is sometimes hard for them to learn something. This can also help improve their points of weakness. Students can be supported to match their learning style with the teaching style of the teacher. Thus, synchronizing the teachers' teaching method with the students' learning style can be a good path towards educational progress of the students.

In addition to these confirming results, there are a number of studies whose results did not confirm the present research like Sendil Can, Shams Isfahan Abadi and Emamipour [7]. Their results disproved any significant relationship between learning styles and educational progress. One the possible reasons for this disagreement is the difference between the current research's statistical society and the research conducted by Shams EsfandAbadi and Emamipour & Sendil Can.

Another factor which is associated with learning styles and we have pointed in this study is the gender role taking. The results of the present study indicate a significant

difference among boys and girls in terms of reflective observation and active experimentation learning methods. In other words, boys show a significantly higher tendency for reflective observation and active experimentation than girls. These results are in line with the results of the studies conducted by Hikson & Baltimore [17], Knight et al [21], and Heffler [15] and these researchers have not arrived at the conclusion that there is a difference between men and women in terms of Kelb's learning styles and men mostly prefer concrete experience, while women prefer reflective observation. Gender differences in learning methods seem to be justified in 2 ways: the first probable reason can be associated with social and cultural factors. Gender differences can be different and variable according to variations in context [22]. In the same sense, Watkins and Hattie (quoted from Hausny, 2006) have shown that differences among the learning methods of boys and girls is associated with their various learning subjects. The second probable reason associated with gender differences in learning methods is concerned with the very concept of gender. In all researches, we deal with biological differences between men and women, however, if we took a look at the previous researches, we would realize that the majority of such differences are not based upon biological differentiations. As a matter of fact, gender differences in learning methods is mainly a consequence of the socialization process which takes place in the life of everybody. As the educational context changes, these processes also begin to change. The ideas which are in the society and school about the concept of manhood and womanhood finally lead to a path where people begin to think of themselves as men and women. In other words, the develop some form of gender identity on themselves which is formed as a result of participation in social groups [22].

Thus, gender identity (as a psychological concept) and not sex (as a biological concept) can explain many of the procedures associated with gender in education.

5. Applied suggestions

1- The learning style of the participants must be identified with the goal of educational guidance. Students must also be informed of all learning styles and their benefits and limitations.

2- Strategies for applying learning methods which are suitable with gender and other vital components in the educational system of a country must be studied.

3- Attempts must be made to reduce the mathematical anxiety among the students by paying attention to nontraditional educational methods –like using games, solving problems, and motivating students for group work.

4- Reducing the mathematical stress among students through creating conditions and providing strategies for scientifically using what they have learnt on a daily basis.

6. Research Limitations

1- Using self-reporting methods in collecting the data through questionnaires is one of the limitations of this research.

2- Both questionnaires were administered in one day and one particular moment. So, it is possible that the respondents might be influenced by their fatigue.

3- As this research has used the correlational method, it was constrained by the limitations associated with this method. The resulting relationships are merely predictive or synchronic relationships and can not be used for causal inference to action.

4- Shortage of research literature in Iran on mathematical anxiety.

5- Lack of time and approaching the examination time of the schools prevented the responsible school personnel from cooperating with the researcher.

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