

*Full Length Research Paper*

## **The effects of learning styles on high school students' achievement on a mathematics course**

**Nevin Orhun**

Anadolu University, Science Faculty, Department of Mathematics, 26470 Eskisehir, Turkey.

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**This study examined the relationship between learning styles of students and their success on a mathematics course. In this study, the categorization of high school students' learning style scores was defined. The given method for calculating the learning style scores was developed by the author. The purpose of this study was to raise the success level of high school students on a mathematics course. Therefore, whether or not achievement depended on the learning style adopted was examined. From the relationship between the high school students' learning styles and their performance, it was found that assimilators performed better than students with different learning styles. The findings revealed that learning style was a potential tool for the improvement of student performance on a mathematics course. The results determined discriminatory learning styles.**

**Key words:** Mathematics achievement, learning styles, teaching strategy.

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### **INTRODUCTION**

Recent research has indicated that an individual's ability to learn and interact might increase when suitable conditions are met that are appropriate for the individual in terms of pace of comprehension and power of understanding. There are plenty of factors relating to the formation of learning. One of the factors is the personal characteristic, which is resistant to change. Once you have determined the correct way to teach students, depending on their perceptive skills, it simplifies the process of selecting the appropriate teaching strategy.

All students learn, but they do not all learn in the same way. Some grasp information best by listening, while others learn better through reading, reasoning, or discovering concepts through a hands-on experience. These different ways of learning are referred to as learning style (Novin et al., 2003).

Learning style implies that what individuals learn has more to do with whether or not their educational

experience is increased as a result of their particular learning style. In a traditional classroom environment, instructors may present information using their own personal style of instruction. If the instructor's style of instruction is conducive with the majority of the learners' learning styles, then the class as a whole will perform well (Gilbert and Han, 1999). Hartman (1995); Jensen and Wood (2000) suggest that the ideal classroom would include each of the four processes in the Kolb cycle. That is, full comprehension requires learning activities fitting each stage of learning.

The ability to learn is a vital characteristic of humans. Humans develop behaviour and the attitudes that they need, through the impact of their environment and endowments. This ability to learn directly affects their causal life-style. Therefore, modern societies keep enhancing their learning styles (Cuceloğlu, 1991).

Studies conducted in the first and second quarter of the

twentieth century point out that any institution that is related to education has reached a reductionist framework. This classical conditioning switched its purpose to experiential learning theory in the 1990's. The cognitive theorists such as Bloom (1976) investigated the nature of learning via fresh approaches. Learning can be expressed as gathering information, processing information, the improvement of thinking, and the method of selection for attaining knowledge. It has been stated in numerous studies that learning is an abstract time period that is born from personal experience (Mezirow, 1981; Freire, 1985). In other studies, it has been determined that learning is formed by an interaction between the individual and the individual's environment. Furthermore, it creates certain alterations on a person's attitudes in the long-term (Cuceloğlu, 1991; Freire, 1985; Hartman, 1995; Knox, 1986; Sutliff and Baldwin, 2001). In addition, it has been stated that there are plenty of different learning styles depending on the individual. Defining individuals' learning styles helps them to become aware of their weaknesses. Therefore, it helps individuals to promote themselves to a higher personal level in terms of their attitudes and behaviour (Felder et al., 2002; Fallan, 2006). Dunn and Dunn (1993) describe learning style as "the way each learner begins to concentrate, process, and retain new and difficult information". Kolb (1985) describes learning style as "the way we process the possibilities of each new emerging event which determines the range of choices and decisions we see, the choices and decisions we make, to some extent determined by the events we live through, and these events influence our future choices. Human individuality results from the pattern or program created by our choices and their consequences." In order to determine the best way to learn to use certain personal skills, numerous studies have been conducted. One of these studies is Kolb's learning style inventory. In Kolb's study, learning styles are defined by a circle and the position of the individual in this circle is determined. According to Kolb's learning theory, the definition of learning is gathered by converting the information into the experience. The common purpose of studies in the field of mathematics education is to enhance the success of students. Therefore, recent studies focus on this purpose overall. According to these studies, the reason for failure is mainly due to inconsistent teaching methods and wrong learning styles (Ronald et al., 1992; Hartman, 1995; Schroeder, 1993; Montgomery and Groat, 2000). Ozgen and Bindak (2012) examined student opinions on computer use based on the learning styles in mathematics education. They show that students with a diverger and accommodator learning styles have more positive opinions regarding computer use in the mathematics education compared to students with other learning styles. Orhun (2007) point out statistical significant difference in achievement and attitude towards mathematics of university students with different learning

styles.

Instructors should be aware of the application of proper teaching methods in order to increase their students' success. Once instructors determine the most accurate teaching method, depending on the level of the students, it becomes simple to select the proper strategy to apply to students (Arslan and Aksu, 2005). There are many studies that show that success and performance increase when the correct teaching style matches the right learning style (Novin et al., 2003; Knox, 1986; Holvikivi, 2007; Felder et al., 2002; Goold and Rimmer, 2000). The harmony should be maintained. It is not easy for someone to change their own learning style. However, this might be changed through experience and time. The teaching method that focuses on students' preferences and their skills increases their motivation as well as simplifying the way they understand.

In this paper, the dominant learning style's effect on the achievement of high school students on a mathematics course was investigated.

## METHODOLOGY

The purpose of this study is to investigate whether success on a mathematics course depends on learning style or not. The subjects were high school students ( $n = 151$ ) in grade 12 from three mathematics classes in the academic year 2011. The study involved collecting data from two sources: the Learning Style Inventory (LSI), and the Grades of Achievements Acquired on a mathematics course (MA).

### Learning style inventory (LSI)

The learning style of students was measured using the Learning Style Inventory (LSI) developed by Kolb (1985). The LSI has been a very useful tool in contributing to our understanding of the role of individual differences in the learning process.

Kolb (1985) theorizes that learning is a four-stage process involving concrete experience (CE) (feeling), reflective observation (RO) (watching), abstract conceptualization (AC) (thinking), and active experimentation (AE) (doing). Kolb also states that pairs of these activities may be represented along two dimensions of active-to-reflective (defined as doing-watching) and concrete-to-abstract (defined as feeling-thinking). Individuals classified as being more active than reflective and more concrete than abstract by Kolb (1985) are called accommodators (AC), whereas more abstract than concrete individuals are called convergers (CO). More reflective than active and more abstract than concrete individuals are called assimilators (AS), whereas more concrete than abstract individuals are called divergers (DI). The four learning styles are represented by the four quadrants of the plane, as shown in Figure 1.

The LSI instrument used in the study consists of twelve incomplete statements, each with four possible completion phrases. Students were asked to rank the completion phrases, numbered from 1 to 4, according to how they felt personally when they were applied to them. A ranking of '1' was used for the completion phrase that least resembled the way a student learned; a ranking of '4' was used for the completion phrase that most resembled the way a student learned.

Some of the verbal content of the learning style inventory is given as follows:

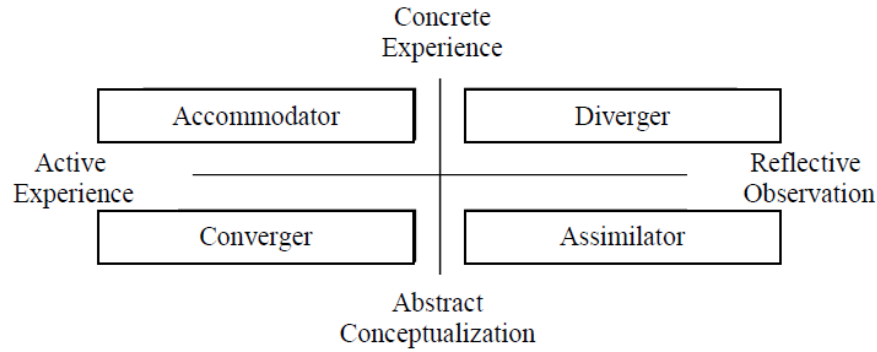


Figure 1. Kolb's learning styles.

		I like to see results from my work	(RO)
Example 1	When I learn	I take my time before acting	(AE)
		I feel personally involved in things	(CE)
		I like ideas and theories	(AC)
Example 2	I learn best when	I rely on my observation	(RO)
		I can try things out for myself	(AE)
		I rely on my feelings	(CE)
		I rely on my ideas	(AC)

The results indicate the learning modes of students in four categories. As mentioned earlier, these categories are concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The concrete experience (CE) mode describes people who learn by feelings. The reflective observation (RO) mode describes people who learn by watching and listening. The abstract conceptualization (AC) mode describes people who learn by thinking. The active experimentation (AE) mode describes people who learn by doing. The learning style of each individual is obtained from a combination of the four learning modes. In order to describe the students' learning styles, firstly, the total score for each of the four learning modes (RO, AE, CE, AC) is calculated over the twelve items. The results of the four learning modes are then combined to classify each student into one of the four learning styles Accommodator (AC), Converger (CO), Assimilator (AS), or Diverger (DI) (Figure 1). That is, the AE-RO points on the horizontal axis, and the AC-CE points on the vertical axis are found. Positive scores obtained from AE-RO indicate that learning is active, but negative scores indicate that learning is reflective. Similarly, positive scores obtained from AC-CE indicate that learning is abstract, but negative scores indicate that learning is concrete (Kolb, 1985). The point at which the coordinates are AE-RO, and AC-CE, is determined. So, the (AE-RO, AC-CE) points are plotted on a plain. The region where the points are consisted, indicates the student's learning style (Figure 1). Hence, the learning style of students was found using LSI developed by Kolb (1985) and the score of the learning style was calculated using the equation developed by the author. The length of the location vector of the point (AE-RO, AC-CE) is the student's learning style score (Figure 2). Ordered coordinate pairs (AE-RO, AC-CE) are in one-to-one correspond with points in the plane. For this reason, we can determine the learning style exactly. After then, we draw the graph of learning style of students with same learning style.

**Example:** If we analyze a student's learning style scores, let us say that the student's AE point is 27, RO point is 43, AC point is 36 and CO point is 14

Therefore,  $AE-RO = 27 - 43 = -16$ ,  $AC-CO = 36 - 14 = 22$ .

This student's learning style is the region in which the point (-16, 22) is consisted. This type of learning style is the assimilator learning style. The length of the location vector of the point (-16, 22) is shown as  $\sqrt{(-16)^2 + 22^2} \cong 27$ ; thus, the assimilator learning style score is 27 (Figure 2).

In the literature, there is no method for obtaining a learning style score. The given method for the calculation of a learning style score has been developed by the author. Determination of learning style score as defined in this paper can drive new studies.

**Examples:**

- What is the role of learning style in the profession choice?
- What is the relationship between learning style and qualifications of student?

The Kolb LSI was used to classify all the students into four learning styles. Table 1 shows the spread of the students' preferred learning styles found in this study.

According to the classification results, 28% of the students preferred the converger learning style. A converger perceives reality through abstract conceptualization and processes it through active experimentation. S/he prefers to perceive information by thinking and doing. Students who prefer the converger learning style make decisions and solve problems objectively using factual data. Given recent news coverage regarding creative accounting techniques, it seems appropriate to continue to encourage students in this area. According to the classification results, 34% of the students preferred the assimilator learning style. An assimilator perceives information in an abstract way and processes it reflectively. S/he learns by watching, thinking, and remaining stable, using expert opinion, accuracy, and using detailed information. Students who prefer the assimilator learning style learn best from lectures and demonstrations. Her/his strength lies in the ability to create theoretical models. According to the classification results, 21% of the students preferred the diverger learning style. Divergers are

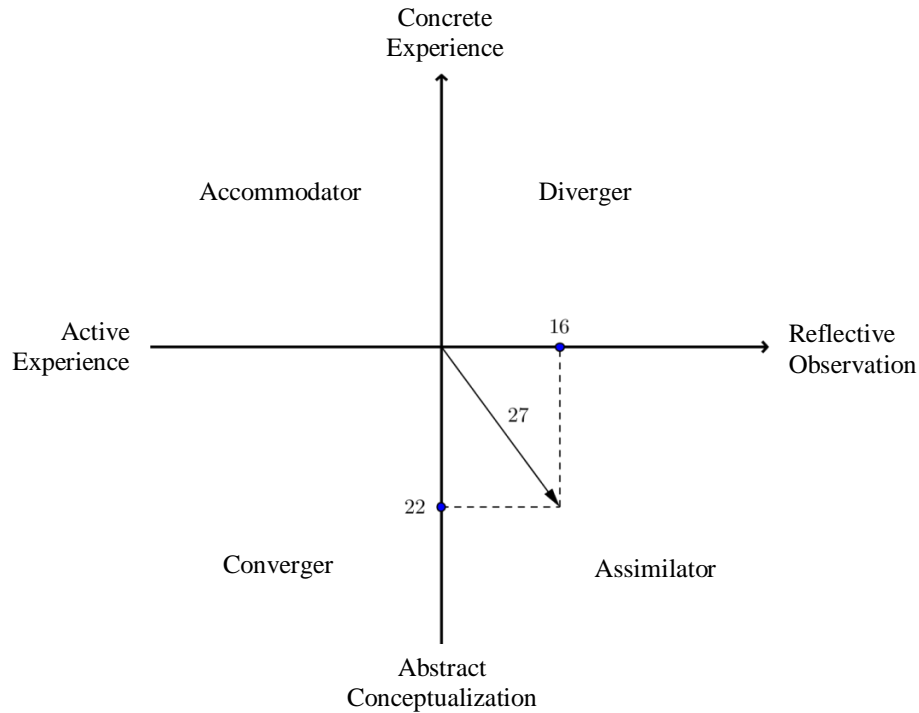


Figure 2. The location vector of (AE-RO, AC-CE).

Table 1. Percentages of students in each learning style.

Learning style	Percentage
Assimilator	34
Converger	28
Diverger	21
Accommodator	17

able to look at things from a different perspective. They are sensitive. They prefer to watch rather than do, and tend to gather information and use imagination to solve problems. They are interested in people, tend to be imaginative and emotional, and tend to be strong in the arts. They prefer to work in groups. 17% of the students preferred the accommodator learning style. The accommodator learning style is hands on, and relies on intuition rather than logic. These people prefer to take a practical, experiential approach to problem-solving. They are attracted to new challenges and experiences, and to carrying out plans.

**Grades of achievement acquired in mathematics (MA)**

The grades of mathematics achievement (MA) were defined by the grade point average at the end of the 2011 academic year. The MA scores were obtained from the school records office.

**FINDINGS AND DISCUSSION**

The data was analyzed using overall learning-style variable comparisons, as well as by a comparison

mathematics achievement. The continuous independent variables were assimilator, converger, accommodator, and diverger learning styles. The continuous dependent variable was the mathematics achievement. A one-sample Kolmogorov-Smirnov test was applied to the variables in the study. As stated in Table 2, related variables are approximately normally distributed. A non-significant result (sig. value of more than .05) indicates normality.

One-way ANOVA was used to compare the mean scores on math achievement. If the ANOVA is statistically significant, it means that there are significant differences in the mean scores on the math achievement across the learning styles. However, the difference in learning styles can not be understood. First, descriptive statistics regarding each learning style were calculated. The mean number for each of the four learning styles categorized is shown in Table 3.

A one-way analysis of variance (ANOVA) was conducted to determine whether or not there was a statistically significant difference in mathematics achievement among students classified in the four learning style categories (Table 4).

The analysis  $F_{(3,118)} = 23.5, p < 0.05; \eta^2 = .374$  (this is a large effect size) shows that there is a statistically significant difference between math achievement (MA) and the four different learning styles categorized for the students enrolled. Appropriate post-hoc test can be used to determine which learning style is different from which other learning styles. In order to see this, Tamhane's T2

**Table 2.** The test of normality.

Null hypothesis	Sig.
The distribution of AS is normal with mean 18.06 and SD 5.22	.870
The distribution of MA-AS is normal with mean 64.50 and SD 17.35	.974
The distribution of CO is normal with mean 24.87 and SD 9.34	.854
The distribution of MA-CO is normal with mean 55.20 and SD 20.59	.848
The distribution of DI is normal with mean 21.97 and SD 12.56	.448
The distribution of MA-DI is normal with mean 39.67 and SD 22.39	.506
The distribution of AC is normal with mean 30.80 and SD 12.79	.925
The distribution of MA-AC is normal with mean 28.13 and SD 11.99	.968

The significance level is .05.

**Table 3.** Means and standard deviation for learning style on MA.

Variable	N	$\bar{X}$	SD
Assimilator	51	64.50	17.35
Converger	42	55.20	20.58
Diverger	31	39.66	22.39
Accommodator TT	27	28.13	11.99

**Table 4.** One-way ANOVA for independent groups.

	Sum of squares	df	Mean square	F	Sig.
Between groups	24105.788	3	8035.263	23.508	.000
Within groups	40332.923	148	341.805		
Total	64438.721	151			

**Table 5.** Test of Homogeneity of variances of math achievement.

Levene statistic	df1	df2	Sig.
5.492	3	148	.001

test was used since the homogeneity of variance assumption was not met (Table 5).

Post-hoc comparisons using the Tamhane's T2 test indicated which learning style is different from which other learning styles (Table 6).

As stated in Table 6, there were significant differences between the groups having assimilator (converger) and diverger learning styles. Also, there were significant differences between the groups having assimilator (converger) and accommodator learning styles. But there were no significant differences between the groups having assimilator and converger learning styles. Also, there were no significant differences between the groups having diverger and accommodator learning styles.

It can be seen that, assimilators and convergers performed better than the divergers and accommodators. In brief, divergers and accommodators had lower means

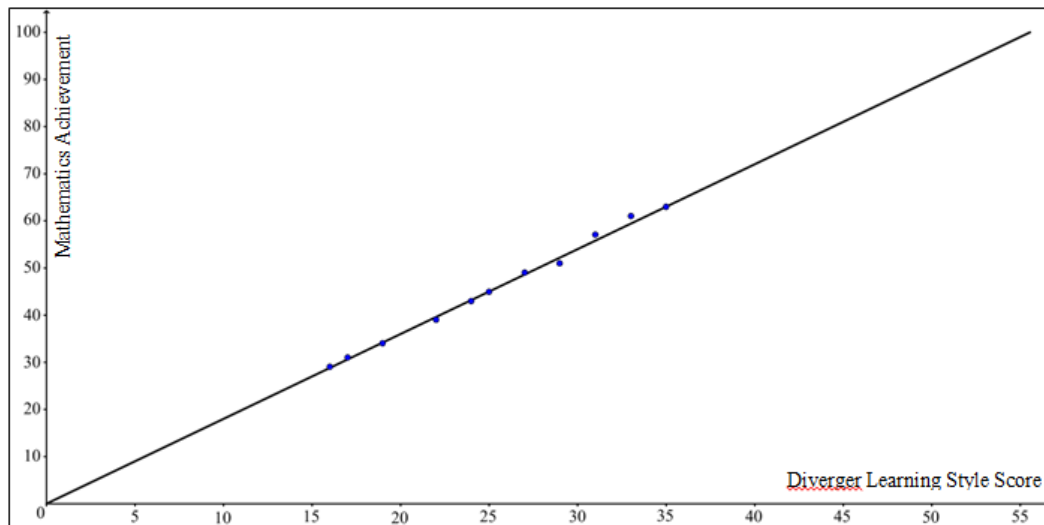
**Table 6.** Multiple comparisons and mean differences among learning styles

Learning style	AS	CO	DI	AC
Assimilator (AS)	-	9.30	24.83 <sup>*</sup>	36.36 <sup>*</sup>
Converger (CO)		-	15.53 <sup>*</sup>	27.06 <sup>*</sup>
Diverger (DI)			-	11.53
Accommodator (AC)				-

\*The mean difference is significant at the .05 level.

which created significant differences in multiple comparisons.

The results of this study demonstrate that mathematics achievement is related to learning style. The learning style score for each student as previously mentioned was calculated. So, it is possible to determine the relationship between mathematics achievement and each learning style graphically. From this, the graph showing the mathematics achievement with learning style scores can be drawn where, the  $x$  coordinate is the learning style score, and the  $y$  coordinate is the mathematics achievement score, such that the  $(x, y)$  points are plotted



**Figure 3.** Correlation of math achievement with diverger learning style scores.

on a plain. Therefore, the scatterplot reveals the relationship between the two variables. Then the best fit for a straight linear regression line is drawn. While drawing a linear regression line which shows the relationship between mathematics achievement and learning style score, the least squares method was used. In order to obtain the relationship between mathematics achievement and the diverger learning style, the diverger learning style score is taken as  $x$  and the mathematics achievement as  $y$ . Then all the  $(x, y)$  points are plotted on a plain, and the best fit for a straight linear regression line is drawn. Figure 3 shows a graph indicating the strength and direction of the relationship between the two variables.

The linear regression line between math achievement and diverger learning style scores was obtained as  $y = 1.8x$ .

Similarly, the correlation of math achievement with assimilator learning style scores, converger learning style scores and accommodator learning style scores is shown in Figure 4.

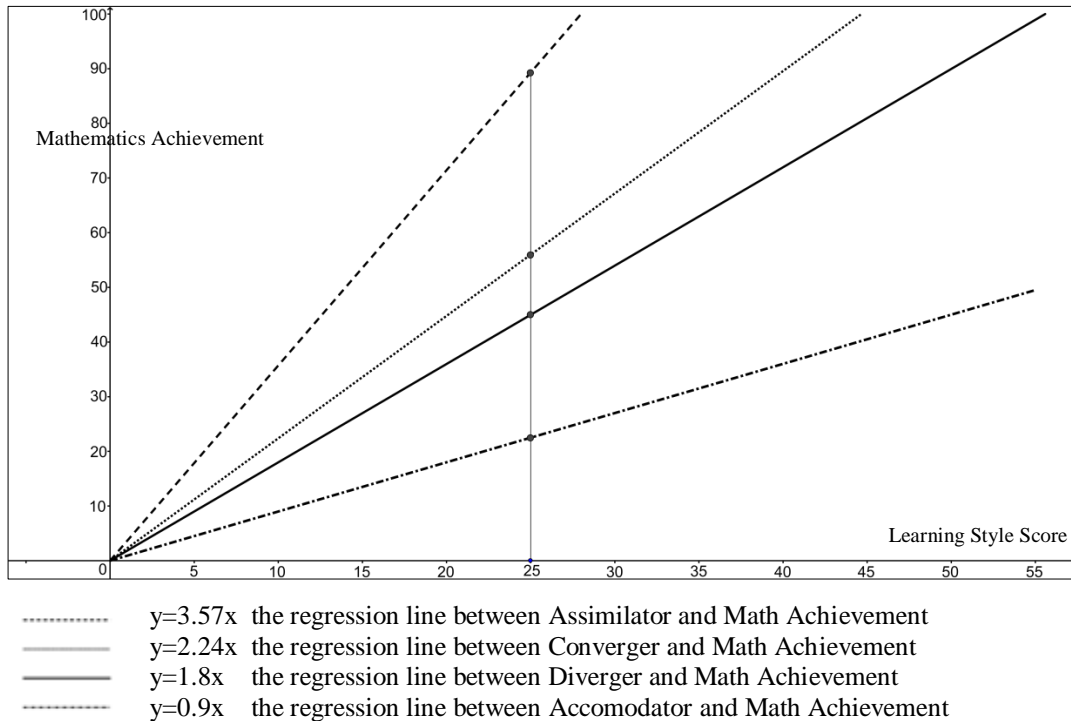
The linear regression line between math achievement and assimilator learning style scores is  $y = 3.57x$ . The coefficient of the correlation is found as  $r = .71$ . There is strength and an increasing relationship between math achievement and assimilator learning style. The linear regression line between math achievement and converger learning style scores is  $y = 2.24x$ . The last linear regression line between math achievement and accommodator learning style scores is  $y = 0.9x$  (Figure 4).

When comparing the math achievement of students who have the same learning style scores, but who are from different learning styles, it is clear that the students with an assimilator learning style are more successful than the others (Figure 4). Then findings of the current graphical analysis show similarities with previous

analyses (Table 5). According to Figure 4, it is obvious that students who have an assimilator learning style have lower learning style scores than the others. This means that the difference in the students' AE-RO and AC-CE scores is very small. Namely, the AE with RO and AC with CE learning style mode scores have nearly close values. In other words, these students have a multi-faceted thinking style and this trait brings success.

### Conclusions and recommendations

It is essential to take students' individual characteristics into consideration when we aim to increase their academic success. As we know, there are many factors contributing to the formation of learning. One of these factors is learning style, which is resistant to change. If students' learning styles are determined, in other words, if we know how they learn, it becomes easier to select the most suitable teaching strategy. In this case, the teaching method might have a strong effect on a student's academic performance. Furthermore, knowing his/her own learning style means that a student becomes a more efficient problem solver. The more successful the individual is in solving the problems s/he encounters, the more effective his/her life will be. A student who knows his/her own learning style develops self-respect because he/she knows how to study and how to prepare assignments, thus becoming more self-confident. In order to achieve effective teaching, it is fundamental for teachers to know their students' learning styles. Teachers should take their students' learning styles into account while they are planning teaching activities, arranging the learning environment, choosing which devices to use, forming study groups and guiding their studies. Teachers with an understanding of their students' learning styles are better able to adapt their teaching methods to suit



**Figure 4.** Correlation of math achievement with learning styles scores.

their students.

In this study, we investigated the relationship between the learning styles of students and their success on a mathematics course. According to our findings, the students in our study have different learning styles, and mostly prefer the assimilator learning style. Assimilators' dominant learning abilities are abstract conceptualization and reflective observation. In order to motivate assimilators, the use of cases that require them to assimilate and synthesize information to establish a theory is important. These learners prefer to observe during learning.

According to the findings, our students' second preference was the converger learning style. Convergents' dominant learning abilities are abstract conceptualization and active experimentation. They are active learners who prefer discovery type inquiry. Convergents make decisions and solve problems by using factual data particularly. To facilitate converger students' learning, their instructors should approach teaching from an objective viewpoint, which allows students to learn by doing and by having them work on problems.

The diverger style was the third preferred style of our students. These are imaginative and emotional individuals. They perceive information concretely and process it reflectively. They prefer to watch rather than do, tending to gather information and use imagination to solve problems.

The accommodator learning style was the least preferred by our students. This learner's educational

background is often in technical or practical fields. They perceive information concretely and process it actively. They work well in groups and enjoy discussion.

While determining the purpose of a mathematics course, students' personal skills should be considered. For an effective mathematics course, students should be encouraged to gather formulas and to create equations by themselves, instead of them being given the formulas and the equations in advance. Moreover, a teaching method has to be decided upon for the students which drive them to use their mental skills in order to find fresh information by themselves.

The results show the importance of a diversified teaching approach that includes all learning styles as defined earlier. Acknowledgement of students' individual learning styles can play a critical role in the learning process. Consequently, the use of formal learning style assessments can provide useful information that can benefit the student as well as the instructor. In conclusion, once you determine how to apply the correct teaching method according to students' perceptive skills, it simplifies the process of selecting an appropriate teaching strategy. As a result, the strategy selected through the students' characteristics of learning will greatly influence the students' performance in class. Generally, from this research, it can be observed that the learning styles can play an important role in the learning process. A better understanding of the learning styles of students can help the instructor to design lectures and to reach all students. The findings revealed that learning

style was a potential tool for the improvement of student performance on a mathematics course.

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