Learning Styles in the Context of Reasoning and Problem Solving Ability: An Approach based on Multivariate Analysis of Variance

Mehraj A. Bhat

Department of Education, Jammu and Kashmir, India

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ABSTRACT

Reasoning and problem solving skills are not just for researchers; they are also progressively significant for making knowledgeable decisions in our everyday lives. Showing variations in learning styles have any influence on these skills? The current state of research address the learning styles in context of reasoning and problem solving ability. High school students (598) completed the reasoning ability test, problem solving ability test and learning style inventory. SPSS software was used for evaluating data obtained from three measurement tools. The entire three tools were validated through different techniques and found significant and acceptable. The data was analysed by using MANOVA and Scheffe's post hoc test. The results indicated that participants showed variations in reasoning and problem solving ability while using learning styles. Moreover, students having assimilating and diverging learning styles possess better reasoning and problem solving ability skills. The results of this research will contribute to the literature of learning styles and cognitive abilities, as well as provide a wide range of implications for class room teachers, curriculum developers, researchers and educational planners.

1. Introduction

During the last few decades, there has been a radical change in every field on account of scientific inventions and technological advancement. To meet the challenges and requirements of this fast developing society, young people need to grow in the ability to think rationally and to express their thoughts clearly. Independent thinking, careful analysis and objective assessment contribute to success in any field (Gardner, 1985). The cognitive abilities play an important role in daily routines and patterns of the learners in general and education in particular. It is universally acknowledged fact that the progress of any nation depends mainly on the utilization of potential of its intellectually talented individuals to the maximum (Asch, 2002).

The students use different thinking styles to accomplish new information and to approach and manage a learning task, selecting those styles with which they are at ease (Zhang & Sternberg, 2000). Students differ in how they receive, recognize and process the information. There are various cognitive factors whose recognition is very essential and they help the learner in academic pursuits. Does receiving and processing information make difference in reasoning and problem solving ability? The investigator tries to answer this question by investigating learning styles in relation to reasoning and problem solving ability.

[1] Corresponding author's address: Department of Education, Govt. Degree College Bijbehara, Jammu and Kashmir, India.
e-mail: mehrajsc@gmail.com

1.1. Relevant Prior Research

1.1.1.   Learning styles

The concept of "learning style" was introduced by Dunn and Dunn in 1960 (Can, 2009). According to them learning style is the way through which each learner begins to concentrate on, process, absorb, and retain new and difficult information (Dunn and Dunn, 1992; 1993). Similarly Kolb (1984) describes learning styles as individual preferred ways while they receive and process information. The purpose of knowing the learning style of students are empowered to understand their strengths and weaknesses, maximize their learning potential, make transitions to higher levels of personal and cognitive functioning and it allows educators to cover materials in a way that best fits the diversity of the classroom. One of the reasons for the development of this term is that learning style has practical application predominantly in the areas of teaching and learning (Baraz, Memarian and Vanaki, 2014).

Subsequently, various studies were conducted on the application of learning styles in several cognitive variables. For example the results of Verma (1988) indicated that extrovert and introvert students were more alike than different in their learning style preferences. Anxiety and learning style preferences are not contingent upon each other (Verma, 1989). While as Verma and Tiku (1990) indicated that the main and interactional effect of socio-economic status and intelligence was not found significant on learning styles. Further, no significant relationship has been found between creative personalities and preferred learning styles of adolescent female students (Verma, 1992). Besides, Verma (1997) reported intellectually gifted adolescent students prefer different learning styles.

However, Afshar, Sohrabi and Mohammadi (2014) found no significant relationship between the learners' learning styles and their English language achievement. The students' achievement levels did not differ significantly according to their learning styles (Bicer, 2014).The results of Eishani, Saad and Nami (2013), also showed that there is significant relationship between learning styles and creativity. The results of Hames and Baker (2014) indicated that the global–sequential, active–referential, and visual–verbal FSILS learning styles scales are related to performance on cognitive tasks.

1.1.2.   Reasoning Ability

The development of reasoning skills, its improvement and various approaches have brought out immediate concerns of educators, psychologists, and philosophers for decades (Bhat, 2014). Reasoning is a very important aspect of human existence. In today's complex world, the ability to think and reason logically is essential for everybody. The ability to reason is indispensable when problem solving skills are required. Without reasoning, already acquired knowledge and experiences cannot be applied to new situations. According to Leighton & Sternberg (2004), "Reasoning, the mediator leaves its mark on almost everything we do and think. This is because almost everything we do and think involves drawing conclusions. When we learn, criticize, judge, infer, evaluate, optimize, apply, discover imagine, devise, and create, we draw conclusions from information and form our beliefs".

The number of researchers (Ertepmar, 1995; Cavallo, 1996; Abdu, 1998; Johnson and Lawson, 1998; Sungur et al. 2001; Kuhn and Holling, 2008; Tekkaya and Yenilamz, 2006; Oloyede 2012, Gupta, 2012; Nnorom, 2013; Kanchan and Sharma, 2013) have found reasoning ability influence on academic achievement in various school subjects. Further, gender differences have been found in reasoning ability by some researchers (Valanides, 1997; Yenilmez et al. 2006; Kohn and Holling, 2008; Jeotee, 2012), while Gupta (2012) found no significant gender difference in reasoning ability. However, girls were better in achievement than boys (Yenilmez et al. 2006; Valanides, 1997).

1.1.3.   Problem Solving Ability

The ability to solve novel problems is one of the hallmarks of human cognition, and the study of this phenomenon plays a central role in the foundation of artificial intelligence. Early models of problem solving provided some of earliest evidence for the computational nature of human thought. These accounts remain some of the most precise and detailed in the literature on mental phenomena, and the topic remains a central and important one that deserves continued study by scientists in the cognitive system community (Langley and Trivedi, 2013).

Having good problem solving abilities makes huge differences in the career of students. It helps them to overcome the day-to-day problems more conveniently and easily. They comprehend the classroom situations easily and show better academic pursuits. Besides, those students who possess good problem solving ability, tend to have more critical thinking, decision making, comprehension, which leads them to attain their goals in a better way in almost all walks of life. Therefore, it is imperative that teachers, parents and peer groups should pay more attention towards their wards and develop in them problem solving skills (Bhat, 2016). According to Skinner (1968), "Problem solving is a process of overcoming difficulties that appear to interfere with the attainment of goal. It is a procedure of making adjustment in spite of interference".

While scanning the related literature Devi (2009) and Hedjazi et al. (2012) found positive relationship between problem solving ability and academic achievement, whereas, Udeanii and Adeymo (2011) showed teachers' problem solving abilities and students learning styles had effect on the student achievement in biology. Besides that Darchingpui (1989) revealed that there were sex differences in achievement in science and problem solving ability and type of school favored achievement in science, and problem solving ability. Higher levels of intelligence (verbal) and field-independence contributed significantly to the total variance on problem-solving ability (Dutt, 1989).While as Macpherson, (2002) explained differences in problem-solving ability related to the year of study and existing academic qualification. Moreover, Salami and Aremu (2006) described problem-solving ability as significantly predictive of study behaviour, and Bandhana and Sharma (2012) found significant impact of emotional intelligence and home environment on problem solving ability.

To sum up, the prior studies related to the variables it reveals that learning styles and cognitive abilities appear to be interactively connected, however, students use of learning styles in reasoning and problem solving ability is unclear.

1.2. Current Study

Prior research has established that all the three variables (learning styles, reasoning ability and problem solving ability) are associated with academic achievement and other cognitive variables. However, not much was known about the joint influence of learning styles in relation to reasoning and problem solving ability. In the current research, the investigator sought to fill the existing gap in the literature by directly examining the learning styles in the context of reasoning and problem solving ability.

2. Method
2.1. Participants

The sample of 598 students of the age group 16-17 years were selected from 18 high schools from the two districts of Jammu and Kashmir (India).

2.2. Design and Procedure

Descriptive survey research was used in the present study. The process of description as employed in this research study goes beyond mere gathering and tabulation of data. It involves an element of population/sampling procedure, tools for collecting the data, interpretation of the meaning or significance of what is described. Thus, description is combined with comparison or contrast involving measurement, classification, interpretation and evaluation. In the present study, inferential statistics was used in deducing results from different statistical techniques employed for investigating the comparison of students reasoning and problem solving with their learning styles.

The data was collected with the help of reasoning and problem solving ability test constructed by the investigator and Kolb's learning style inventory (Kolb, 1999) adapted and standardized by the researcher on a sample of 598 students' at secondary school level through stratified random sampling technique.

2.2.1. Reasoning Ability Test

The test consisted of 35 items having four alternative responses. The validity of the test was evaluated through face and construct validity. The face validity was evaluated through experts and to evaluate construct validity, the investigator used two methods i.e. Pearson's correlation (score of each dimension & total score of the test), to know the discrimination validity the investigator use two independent samples 't'

test (compare high and low group) and automatic linear modelling showing the contribution of the test. The test has good accuracy and all the values are significant at 0.01 and 0.05 level (Bhat, 2016).

The reliability of the test was evaluated through Cronbach's alpha having reliability coefficient 0.71.

2.2.2. Problem Solving Ability Test

For problem solving ability, the researcher constructed the test consisted of 20 items having four alternatives. The validity was evaluated through experts (face validity) and for construct validity the researcher used two methods i.e. (i) correlation between items and total score of the test (ii) compare high and low group (discrimination validity). The values were significant at 0.05 and 0.01 level. The reliability of the test was calculated through Cronbach's Alpha Coefficient and it was found to be .729 (Bhat, 2016)

2.2.3. Learning Style Inventory

Kolb's learning style inventory (1999) was used to assess the learning styles of students. It is one of the most well-known and frequently used instruments to assess individual learning style preferences. According to Kolb Individual's learning styles are like a circle, which contain four learning stages. These stages are: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE). The process of learning has two main dimensions. First dimension is reaching from abstract conceptualization to concrete experience, and the second is reaching from active experimentation to reflective observation (Kolb, 1984).

The four learning styles, which are based on this learning cycle as identified by Kolb are: Diverger, Assimilator, Converger and Accommodator. The description of Kolb's Learning Style Inventory is shown in Fig. 1.
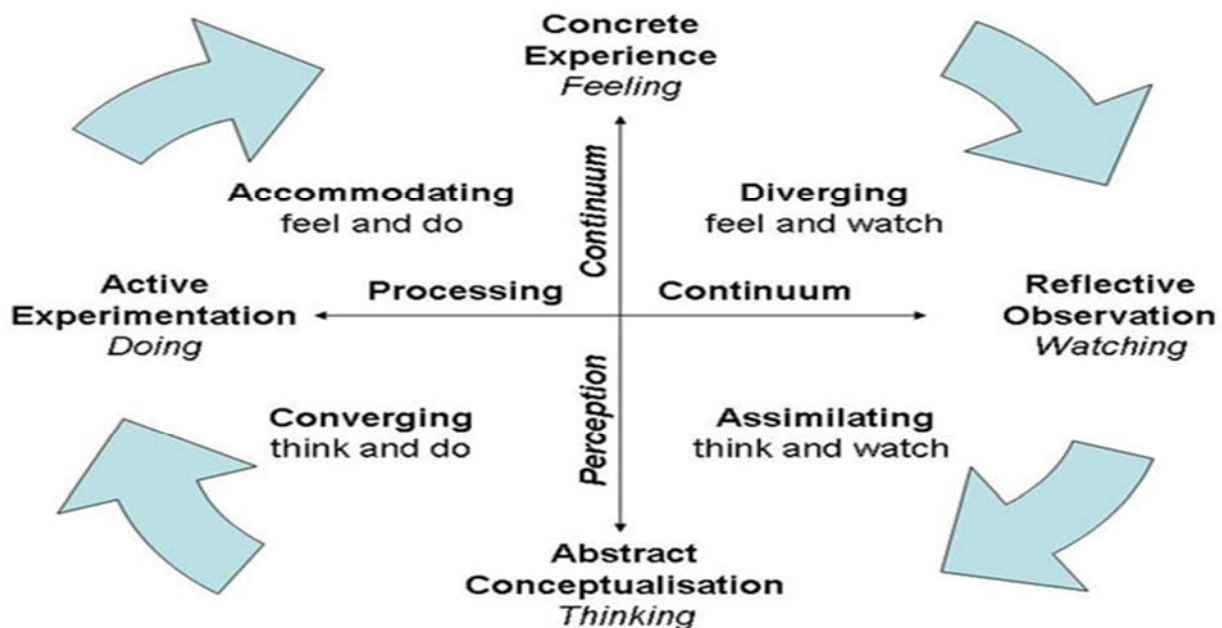

Fig. 1. Graphical Presentation of Kolb's Learning Style Inventory

The inventory consists of 12 sentences each followed by four statements was used to assess the students learning style preferences. In this inventory students are asked to rank each sentences one to four by expressing their preferences. These preferences are then mapped on the four poles: Concrete experience (CE), Reflective observation (RO), Abstract conceptualization (AC) and Active experimentation (AE). The raw scores of the students ranged from 12 to 48. The degree to which one prefers one's ability over another is determined by subtracting the scores from (AC-CE) and (AE-RO). The definite learning style of a student is assessed by plotting the scores of AA-CE and AE-RO on a grid. The scores of AE-RO are plotted on

horizontal axis and the scores of AC-CE are plotted on vertical axis to identify the converging, diverging, accommodating and assimilating learning styles (Farooq and Regnier 2011).

The reliability of the inventory has been calculated by number of researchers. Platsidou, (2009) calculated reliability of Kolb's Learning Style Inventory, through Cronbach Alpha for the four learning modes, Concrete Experience (CE) is 0.81, Reflective Observation (RO) is 0.72, Abstract Conceptualization (AC) is 0.76, Active Experimentation (AE) is 0.76 and found them satisfactory.

Askar (1993) adopted it in to Turkish language and calculated reliability by Cronbach's alpha, Concrete Experience (CE) is 0.82, Reflective Observation (RO) is 0.75, Abstract Conceptualization (AC) is 0.81, Active Experimentation (AE) is 0.82, Abstract-Concrete (AC-CE) is 0.81 and Active-Reflective (AE-RO) is 0.78.

Keeping all these attempts in mind the researcher also measured the reliability of the inventory through Cronbach Alpha which is Concrete Experience (CE).676, Reflective Observation (RO).632, Abstract Conceptualization (AC).570 and Active Experimentation (AE).637 (Bhat, 2016).

3. Results and Discussions

In order to know the significance of difference between the mean scores of learning styles on students reasoning and problem solving ability, multivariate analysis of variance (MANOVA) was used to describe the directed dependencies of reasoning and problem solving ability on students learning styles. The use of the assessment is based on the assumption that learning styles promote reasoning and problem solving ability. With the multivariate analysis, two dependent variables (reasoning and problem solving ability) were examined across on independent variable (learning styles). Thus, one-way MANOVA was used, to measure how students reasoning and problem solving ability scores (in combination) differ with respect of learning styles (multivariate effect). The MANOVA is useful when dependent variables are moderately correlated (0.4 - 0.7). The correlation between reasoning and problem solving ability is shown in table 1.

Table 1. Correlation between reasoning and problem solving ability

Dependent Variables	R	p
Reasoning and problem solving ability	0.556**	0.00

**p < .001

From table 1, the correlation between reasoning and problem solving ability is (0.56) which is within acceptable limit for MANOVA outcomes. As a result, the correlation was not too high of dependent variables; therefore, the investigator precedes the multivariate test.

Besides that, it was necessary to check the Box's Test of Equality of Covariance Matrices. The Box's Test of Equality of Covariance Matrices checks the assumption of homogeneity of covariance across the groups using p < .001 as a criterion. The results are shown in table 2.

Table 2. Box's Test of Equality of Covariance Matrices and Wilk's Lambda Test

Independent and Dependent Variables	Box's M	F	p	Wilks' Lambda	F	p
Learning Styles + Reasoning and Problem Solving ability	9.93	1.645	.13	.934	6.85**	.000

**p < .001

From the perusal of table 2 the F value of Box's M =1.645, (P>.01) hence, no significant differences on covariance matrices. Therefore, the assumption is not violated and Wilk's Lambda is an appropriate test to use.

The table also displays the results of one-way MANOVA, using the Wilk's Lambda test at alpha level of .01. The values (F= 6.85,p < .01) indicate that the test is significant at 0.01 level. The significant F shows significant differences in learning styles on a linear combination of the two dependent variables. It indicates homogeneity of between-group variance for reasoning and problem solving ability scores. Therefore it is concluded that there is a significant multivariate difference for the combined dependent variables of reasoning and problem solving ability with respect to their learning styles.

Table 3. Mean difference and univariate analysis of reasoning and problem solving ability according to students learning styles preferences

Dependent Variables	Learning Styles	N	Mean	S.d.	F
Reasoning Ability	Accommodating	168	24.77	4.52	
	Assimilator	169	27.15	3.48	9.034**
	Converging	109	25.26	4.29	
	Diverging	152	26.05	5.18	
Problem Solving Ability	Accommodating	168	10.53	3.02	
	Assimilator	169	11.75	2.96	8.769**
	Converging	109	10.40	2.93	
	Diverging	152	11.75	3.17	

**p < 0.01

A perusal of table 3 reveals that students with assimilating learning style possess best reasoning ability, as their mean value is 27.15 is high followed by diverging 26.05, converging 25.26 and accommodating 24.77. Similarly students with assimilating and diverging learning style possess best problem solving ability, as their mean value is 11.75 followed by accommodating 10.53, converging 10.40.

In order to know whether the difference in reasoning and problem solving ability in terms of their learning styles is actual or just by chance, univariate analysis has been used. According to the univariate analysis, the students reasoning, problem solving ability scores significantly differ in terms to their learning styles, because the F values (9.03, 8.77 p <0.01) are significant at 0.01 level. The mean difference of learning styles according to their reasoning and problem solving ability has also been represented graphically in figure 2.
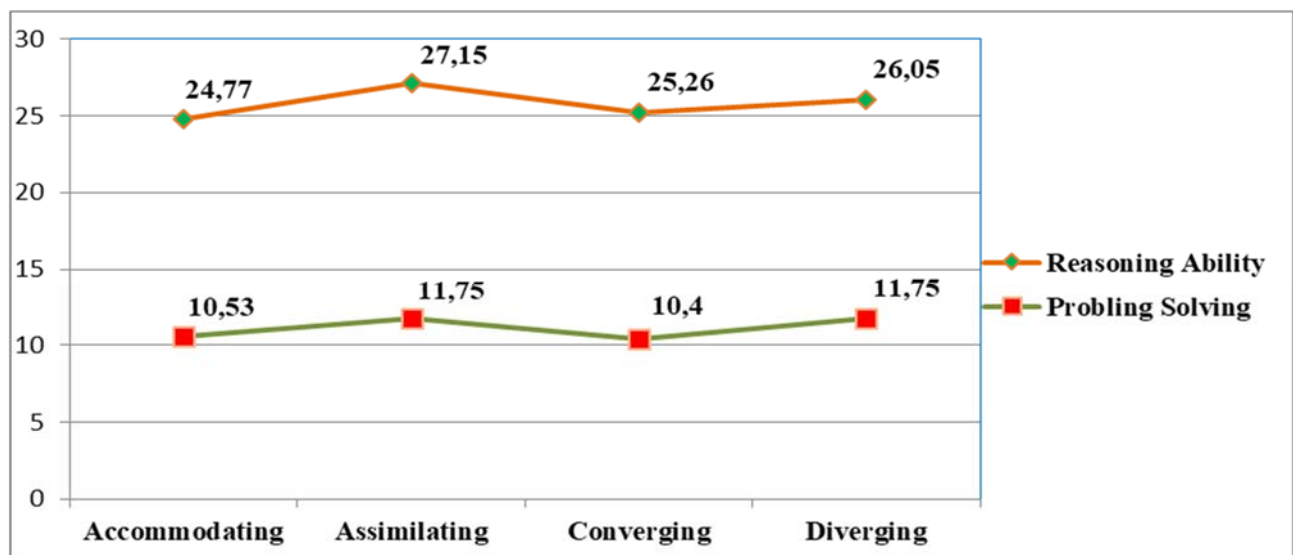
Fig. 2. Graphical presentation of reasoning and problem solving ability means according to students learning style preference

In order to know whether the differences are actual or just by chance within the groups, Scheffe's post hoc test was used.

Table 4. Multiple comparisons using Scheffe's Post Hoc Test

Dependent Variable	(I) Learning Styles	(J) Learning Styles	Mean Difference (I-J)	p
Reasoning	Accommodating	Assimilating	-2.37*	.000
Ability	Converging	Assimilating	-1.89*	.003
Problem		Assimilating	-1.22*	.001
Solving	Accommodating	Diverging	-1.22*	.002
Ability	Assimilating	Converging	1.35*	.002
	Converging	Diverging	-1.35*	.002

**p < 0.05

The table 4 reveals that there is significant difference between accommodating and assimilating, converging and assimilating learning styles so far as reasoning ability is concerned. Similarly a significant difference between accommodating and assimilating, accommodating and diverging, assimilating and converging and converging and diverging so far as problem ability is concerned.

From the results, it indicates that learning styles make the difference with regard to students reasoning and problem solving ability, besides students having assimilating and diverging learning styles possess better reasoning and problem solving abilities. The students who receive and process information through assimilating learning style, prefer abstract conceptualization (AC) and reflective observation (RO). The learners who prefer to such type of learning style tend to have an inductive reasoning and capability to build theoretical models. They have disparate observations into an integrated explanation and are less focused on people and more concerned with ideas and abstract concepts. Their ideas are judged less by their practical values. They have the most cognitive approach, preferring to think than to perform and prefer instructional

methods for their learning. In addition they can understand a wider range of information, which they are capable to coordinate into concise and logical form (Kolb, 1984).

Moreover, assimilating learning style replicates trait of basic mathematics and sciences. Students are motivated to answer the query, 'what is there to know' (Litzinger and Osif, 1993). They focus on abstract concept and thoughts while they learn something. These people prefer to become teacher, sociologist, educationist, advocate, law, librarian etc.

The students who have diverging learning styles learn through feeling and watching. Divergent knowledge is more about creativity. It is about the generation of a number of accounts of experience. According to Kolb (1984) the learners who desire to learn through diverging learning style possess strong imaginative ability, awareness of meaning and values. They do their best in situations that call for generation of alternative ideas and implications such as brain storming, view concrete situations from many perspectives. They organize many relationships into a meaningful "gestalt". Besides that they emphasize on observation rather than action, interested in people and tend to be imaginative and feeling oriented and has broad cultural interests. This type of learning style is a combination of concrete experience (CE) and reflective observation (RO) learning styles. Individuals who own this learning style like to look at things from many perspectives and are very open-minded and prefer to work with people. Generally, other people can easily influence and to get constructive feedback is important for them. Their judgments about any situation are taken very patiently and carefully but they don't like to involve in action. These people choose jobs such as social practices, journalism, psychology, literature and art/theatre (Kolb, 1984).

4. Conclusions and Implications

From the results of the study it has been found that while using different learning styles the students show variations in reasoning and problem solving abilities. Moreover, students having assimilating and diverging learning styles possess better reasoning and problem solving abilities. It is worth to mention that assimilating and diverging learning styles promote reasoning and problem solving abilities. The identification of student learning style helps a student to become an efficient problem solver. The more successful the individual is at solving the problems, the more control one will have over their life. Students should be provided opportunities to receive education in areas suitable for their learning styles. A person educated in an area having no relationship to his learning style may lack confidence, and may result in delayed success.

Therefore, it is emphasized that teachers and students should be familiar of learning styles. They may try to identify their own learning styles. Thus, recognizing students' learning styles may enable teachers to organize their instructions according to their students' individual needs and facilitates their learning. Besides, teaching according to students learning styles may assist students to become more eager about the subject, investigate and understand the facts and most essentially they put into practice what they have learned.

In this paper, Kolb's experiential learning model has been used. It helps students to understand learning and shows flexibility at a deeper and more comprehensive level. The theory also provides practical guidance aimed at helping students to improve their learning and to design better education and development.

The teachers may use various learning style instruments to determine learning styles of their students at the beginning of the academic year. Thus, they may organize instructional strategies according to learning style preferences by their students. Also, in-service teacher training programs may be organized to update teachers about students' learning styles and teaching methods, which are based on students learning styles.

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