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The Predictive Power of Reasoning Ability on Academic Achievement

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Abstract. The present study examined the contribution of six components of reasoning ability (inductive reasoning, deductive reasoning, linear reasoning, conditional reasoning, cause-and-effect reasoning and analogical reasoning) to explain the variation in academic achievement of class 10th students. Through stratified random sampling technique five hundred and ninety eight students solved 35 contextualized different components of reasoning problems standardised by the investigator. The different components of reasoning ability were assessed with help of automatic linear modelling. The predictive power of various components of reasoning ability for academic achievement was 31.5 %. Out of the six dimensions of reasoning ability, the maximum involvement was reflected by deductive reasoning (.49) followed by cause and effect reasoning (.26) inductive reasoning (.16), linear reasoning (.05), conditional reasoning (.03) and analogical reasoning (.02) on academic achievement. The results achieved with the help of this method predicted greater accuracy and authenticity.

Keywords: Reasoning Ability; Academic Achievement; Predictive Power

Introduction

Since the evolution of human beings, reasoning ability has been used as an important element to solve their day to day related problems. It has been acknowledged as the main component of human nature. Its expression can be found in the teaching of Socrates, Confucius and others (Chen, 2000). The aim of education is to equip the people with the ability to reason out. Therefore the development of reasoning skills, its improvement and various approaches invited the attention of teachers, thinkers, and academics for years (Kemler, 1998).

Reasoning is a thoughtful activity that has vital significance during the whole life. All most all the theories of intelligence give much emphasis on the reasoning and have crucial importance in daily routines and patters of life (Wilhelm, 2004).

The students make use of reasoning ability in various life patterns in general and education in particular. It helps students to draw conclusions and these conclusions help them to solve their problems. It assists students in gaining true knowledge, because knowledge is based on logic and rationality. Besides, it helps students in decision making, problem solving, causal relationships, making inductive and deductive generalizations and academic excellence. Studies also revealed that reasoning helps in developing IQ (Leighton & Sternberg, 2004).

In various thought process such as decision making, critical thinking and problem solving, reasoning is pivotal (Samarapungavan, 2009). The researchers (Tella etal, 2008) claimed that pupils' reasoning ability is an essential condition for the assessment of the performance in learning and is also an indicator of their future performance. Moore and Bruder (1996) highlighted the significance of reasoning ability they stated that reasoning skills help students think clearly and logically to act upon multiple problems with a rational approach.

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 (Bhat, 2014).

Progressive psychologists explore the growth and expansion of reasoning from birth to maturity. The first comprehensive theory of reasoning development was Piaget's theory of cognitive development (Demetriou, 1998). Cognitive psychologists and mathematics teachers have great interest in area of reasoning (National Council of Mathematics Teachers [NCTM], 2000). Without reasoning, already accomplished knowledge and experiences cannot be applied to new situations. Reasoning is broadly defined as "the process of drawing conclusions" (Leighton and Sternberg, 2004, p. 3, 4). The true conclusions assist in problem solving because they are reliable representations of the external environment. Therefore, the main aim of education is to make available the situations which will stimulate the students' with reasoning abilities (Valanides, 1997).

Various Dimensions of Reasoning

Earlier there were two categories of reasoning such as inductive and deductive made by philosophers. Later on abduction was introduced and finally it was acknowledged that there are three categories of reasoning (Allan, 2006). Roediger & Rushton (1987) in their book "Psychology" has mentioned some types of reasoning, like- conditional, analogical and linear reasoning.

Although, there are some more categories of reasoning from which some are not familiar. These are cause-and– effect reasoning, comparative reasoning, criteria

reasoning, decompositional reasoning, systematic reasoning, syllogistic reasoning (Vince, 2011; Shank, 1998; Wason and Johnson, 1972; Jeotee, 2012).

In the present study the researcher selected six types of reasoning (inductive reasoning, deductive reasoning, linear reasoning, conditional reasoning, cause-and-effect reasoning and analogical reasoning) because these are widely applicable in daily routines and patterns of life in general and classroom situation in particular. The brief descriptions of them are as:

In inductive reasoning one can articulate generalized principles and inferences on the basis of certain evidences (Mangal, 2007). However, the deductive reasoning is a process of drawing inferences on the basis logic and fact. In this type of reasoning one can draw logical inferences from identified reports or indications. The conditional reasoning encompasses making conclusions with given major evidence (Markovits and Barrouillet, 2002). Similarly, the linear reasoning involves straightforward relationship among elements (Mangal, 2007). The analogical reasoning is the capability to identify and practice interpersonal resemblance among conditions or actions and is a basic feature of human perception. It is an essential method in scientific results and problem-solving, classification and decision-making (Gust et al. 2012). Lastly Cause-and-effect reasoning observes the reasons of definite activities, occasions, or circumstances (causes) make specific concerns (effects)". It is central to human reasoning in everyday life as well as in other disciplines (Robert, 2005).

Relationship between Reasoning ability and Academic Achievement

Academic achievement has become an indicator of a child's future in the present extremely competitive world. Many students seem not to get recognition proportionate with their known or related abilities. Generally, we find students with average abilities excel in different areas. The perplexing facts, which have come into forefront, are that in spite of having similar educational amenities, atmosphere, desires etc. academic achievement of students differs from one another (Gakhar & Aseema, 2004). Therefore, the topic of academic achievement has assumed a lot of meaning in the modern educational system.

In our social set up, academic achievement is considered as a main standard to judge one's whole capabilities and competencies. Therefore, academic achievement occupies an essential place in teaching learning process. In the present socioeconomic and cultural context academic achievement is of paramount significance. Right from the beginning great stress is placed on achievement at secondary school level (Gupta, Sharma & Gupta, 2012). This stage has its own organized hierarchy which is mainly based on achievement and performance, because this period is a path to enter professional courses.

The academic achievement is a multidimensional and multifaceted phenomenon. There are various factors, which influence pupil's academic achievement viz. school climate, parental involvement, intelligence, learning experiences at schools, parental occupation, their educational level, reasoning, personality, motivation, heredity, problem solving interest aptitudes, learning styles and socio-economic status of the parents and many more factors (Can, 2009).

In the present times everyone desires to have a high academic performance. The entire system of education is centred on students' academic performance. An insignificant research occurs concentrating on the role of reasoning ability on pupils' performance in science and other subjects but they are limited and inconsistent. The results of Ertepmar (1995) and Oloyede (2012) found that formal reasoning ability as a strong predictor for the achievement in chemistry. It has been also studied that reasoning can be used to predict the performance of students' achievement in chemistry (Abdu, 1998). The results of Sungur et al. (2001) also indicated that reasoning ability significantly affects students' achievements. Tekkaya and Yenilmez (2006) discovered that reasoning skill was the chief predictor of understanding, showing 31% of variation. Kuhn and Holling (2009) showed that reasoning ability appears to be significant for predicting academic achievement in science. The results of Nnorom (2013) depicted that those students who had high reasoning ability achieved better in biology than the students who had low reasoning ability.

However, the above studies suffer from one or more shortcomings. These are as:

- Reasoning ability was frequently measured using an insignificant, haphazard set of tasks. The resulting representation of the paradigm is therefore contaminated by task-specific variance and does not necessarily replicate all appropriate characteristics of reasoning ability.
- Similarly, studies relating reasoning ability and academic achievement showing variations in their results, due to some extraneous errors in the data, therefore results are not conclusive.
- Besides, most studies usually focused on a single construct of reasoning ability, such as inductive reasoning or deductive reasoning, which fails to provide a synthetic view of reasoning ability.
- The tools used to measure reasoning ability were not accurate with respect to their constructs and sometimes vague from common reasoning tasks. This problem is apparent, e.g., in the work of Valanides (1997) used Test of Logical Thinking (TOLT) to measure formal reasoning ability where the same type of test served as a formal operation performance (1998) task in another. The test used to measure formal reasoning ability have several common characteristics with those used to measure formal operation performance, it is not clear which characteristics are accountable for the high correlation acquired between them.
- Previous researches used common techniques (linear regression analysis) to know the effect of reasoning ability on students' achievement. Nevertheless, this aspect of the program also has shortcomings. According to Yang (2013) linear regression is restricted to the stepwise process merely having no competence of showing all feasible subsets of regression. It is restricted in terms of optimal statistics for variable collection and present standards are in the practice of significance assessments liable to to Type I/II errors. Besides, linear regression analysis incapable to automatically ascertain and handle distant cases and finally incapable to conduct model together to improve predictions.

Current Study

The present study addresses these issues by using reasoning ability tasks carefully selected from previous researches to represent all aspects of reasoning ability to know the power of different dimensions of reasoning ability on the students' academic achievement. Furthermore, investigator investigated the predictive power (whether predictor variables account for variability in a dependent variable) of reasoning ability on academic achievement by using different method (automatic linear modelling). This quickens the data investigation procedure through numerous automatic mechanisms. The innovative technique is an enhancement over the outdated method in the limitations drawn above. Predominantly, two main areas of development are in involuntary variable selection and involuntary data planning.

Method

Participants

Participants were 598 of the age group 16-17 years. The students were selected from 18 high schools from two districts of State J&K (India).

Design and Procedure

In the present study the investigator used survey method. The data was collected with the help of reasoning ability test having six dimensions (analogical, linear, conditional, deductive, inductive and cause and effect reasoning) constructed by the investigators on a representative sample of 598 secondary school students through stratified random sampling technique.

The reliability was calculated through Crombach alpha having reliability coefficient 0.71 and the reliability for each dimension is .65, .75, .63, .65, .73 and.71 respectively.

The validity of the test was evaluated through face validity and construct validity. The face validity was evaluated through experts and to evaluate construct validity of the test, the investigator used two methods i.e. relationship between the total score of test and scores of each dimension (using Pearson's correlation) and compare high and low group to know the discrimination validity (two independent sample 't' test) of the test. All the values are significant at 0.01 and 0.05 level.

For academic achievement the researcher used previous marks obtained by the schoolchildren in the final end term examination (2013-2014) conducted by Board of School Education. The marks were collected from students' results records kept in the respective schools.

The following criteria were kept in mind for using academic scores as measure of achievement:

i) The annual examinations are conducted by State level body, thus contain objectivity and comprehensiveness.
ii) The marks are the sum total of all the subjects taken together, thus controlling all the intervening variables.

iii) Experts of different subjects prepare the exam papers, thus papers may be considered as standardized tests.

iv) Marks include performance on theoretical, practical as well as internal assessment. Thus the annual scores are reliable, dependable and give complete report of overall assessment of the child.

Besides, it has been also found that a number of researchers (Uzuntiryaki, 2007; Kuhn and Holling, 2009; Ghazvini and Khajehpou, 2011) have used academic achievement scores as measures of academic achievement.

Results

In order to know the end product of different dimensions of reasoning ability on students' achievement, automatic linear modeling has been used with the help of SPSS 20. The data for the same is presented in figure 1, table 1 and figure 2.

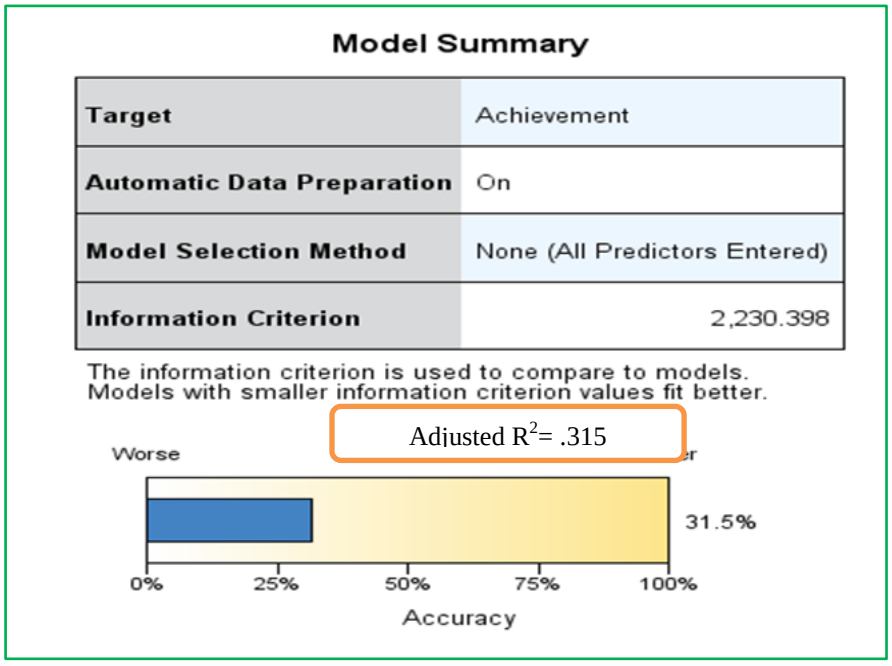

Figure 1: Model Summary of Reasoning ability on Academic Achievement

From the above model it indicates that 31.5% of variance in academic achievement is explained by different dimensions of reasoning ability, it reflects that model has accuracy. The model also shows the effect and importance of various dimensions of reasoning ability on academic achievement which is shown in table 1.

Table 1: Effect and Importance of Different Dimensions of Reasoning Ability on Academic Achievement

Effects

Target: Achievement

Source	Sum of Squares	df	Mean Square	F	Sig.	Importance
Corrected Model ▼	11,597.017	7	1,656.717	40.307	.000	
Deductive_transformed	5,640.400	1	5,640.400	137.228	.000	0.486
Cause.and.effect_transformed	3,029.348	2	1,514.674	36.851	.000	0.261
Inductive_transformed	1,885.925	1	1,885.925	45.884	.000	0.162
Linear_transformed	567.902	1	567.902	13.817	.000	0.049
Conditional_transformed	306.409	1	306.409	7.455	.007	0.026
Analogical_transformed	176.217	1	176.217	4.287	.039	0.015
Residual	24,250.396	590	41.102			
Corrected Total	35,847.413	597				

The table 1 shows that all the dimensions of reasoning ability are important predictors and have significant importance on academic achievement. Further the table 1 shows that all the F values of different dimensions of reasoning ability (F=137.29, 36.85, 45.88, 13.82, 7.46, 4.29 P < 0.01, 0.05) are significant at 0.01 and 0.05 level. Thus, it can be concluded that each dimension of reasoning ability have significant effect and importance on academic achievement. Out of the six dimensions of reasoning ability, the maximum importance is shown by deductive reasoning 0.49 followed by cause and effect reasoning 0.26, inductive reasoning 0.16, linear reasoning 0.05, conditional reasoning 0.03 and analogical reasoning 0.02 on academic achievement. The model depicts the graphical presentation is shown in figure 2.

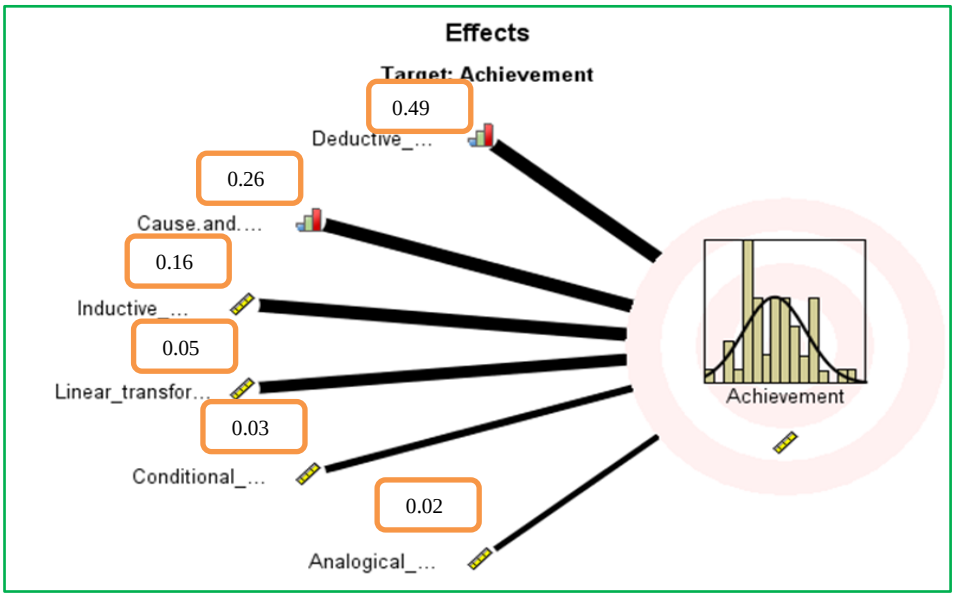

Figure 2: Effect of Different Dimensions of Reasoning Ability on Academic Achievement

Conclusions

According to the results of the study it has been found that reasoning ability seemed to be the main predictor of academic achievement. This means that having greater reasoning ability promotes better academic achievement. There is also evidence from the present study that students show competence in different reasoning components. The individual differences in reasoning ability could be explained by performance in academic achievement. The results which have been drawn with the help of automatic linear modelling showed greater accuracy, compatibility, authenticity. Therefore, it is imperative to foster reasoning ability among students, so that they could excel in all walks of life in general and academic pursuits in particular.

It is further suggested that schools should make provision for materials that can stimulate the reasoning ability of the students. Things like computer games, fascinating objects, simulation and games of different kinds may be provided. It becomes progressively imperative to develop reasoning ability through all-time learning so that the learner may be able to face challenges and may lead important life, and build a balanced world (Shu, 2000). Hence, present systems of education all over the world have acknowledged the need and improve pupils reasoning ability (Moshman, 1990; Wu, 2001). Besides, teachers should ask the students' questions like 'why' and 'why not' and cultivate the habit of 'if-then-else'. Teachers can also play an important role by adopting various strategies and techniques, which help in the development of reasoning ability. They can help students to develop their advanced levels of reasoning through careful range of tasks and the use of probing questions so that students may learn problem solving approaches and use the power of extra formal reasoning to better formulate and justify mathematical calculations. The continuous development of mathematical reasoning habits should be given priority in the high school students.

From the findings of the study it has been also revealed that out of the six dimensions of reasoning ability, the maximum importance is of made by deductive reasoning (0.49), cause and effect reasoning (0.26) and inductive reasoning (0.16), on academic achievement. Therefore, it is imperative that school teachers should promote these types of reasoning among school going students.

Moreover, teachers should to plan their lessons and classroom setting according to learners reasoning ability. School administrators may put extra efforts to embed curriculum with reasoning and skills, so that students may get opportunity to sharpen their skills.

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