Reasoning ability as a determinant of engineering aptitude: a study on engineering student of Durg-Bhilai Region, India

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Abstract

Employment in engineering warrants for a variety of skills, Industry is increasingly looking for employees who can think holistically, who can innovate, who can work in teams, who can synthesize and who can think critically in decision making situation. Present engineering education system do check basic Math's and Science skill before selecting student for the course. These skill though important does not impart necessary aptitude for becoming a good engineer. This study try to find the relationship of reasoning skill of an individual with his engineering aptitude. A strong positive co-relationship has been concluded in the study between reasoning skill of an individual and his engineering aptitude. A model to explain engineering aptitude of the graduate engineer has also been constructed and it has been concluded that more than 30% of the engineering aptitude variation is on the account of individual reasoning ability. This calls for a introduction of some weight age of reasoning question in the engineering entrance test to select a graduate engineer with right aptitude.

Keywords: Reasoning, determinant, engineering, aptitude.

Introduction

While the Indian advanced education framework has gained extensive ground as far as capacity creation and enrolment in technical institution is concerned, in the most recent decade, it slacks essentially as far as worldwide significance and competitiveness concern, of its graduates. The engineering graduates who pass out from various institutions are not fit to be employable just after their education. The reason for this is mainly due to two facts, first the technical education system in India is mostly inclined academically and there is lesser importance given to practical aspect of engineering.

Secondly the students who are selected to become future engineers lack certain aptitude that is crucial for success in engineering jobs.

This study examines the second factor about the lack of employability skill of engineering graduates. Employability skills and aptitudes are general abilities that are expected to be possessed by individual to land most of the technical job, however desired aptitude additionally help one to remain in a employment and work his way to the top. While the desired aptitude will be dependable on some occupation, most Engineers will likewise need to have some broad abilities.

It doesn't matter if one is a engineer involved in designing, engineer in charge of taking decision, or engineer in other role, a person requires some aspect of rational thinking and reasoning skills. Most of the engineering profession relies on clear, concise, and rationale decisions and these decisions only come about through a structured process of thought.

Without a critical thinking and reasoning process for decision-making in place one might not be able to take decision which are agreeable to most of the beneficiaries. The importance of developing critical thinking and reasoning skill are: i. Critical thinking improves the repetitive pattern for execution, research the idea generation and action orientation. ii. Aids in data driven decision making process, and also improves the quality of decision.

The reasoning skill can act as a important factor in developing the engineering aptitude among young engineering graduates. Though reasoning skills can be developed to some extent during the course of graduation it will be a good idea to select those student for entering into engineering course that do posses a high critical and reasoning skills.

In this study firstly, previous work on reasoning skills and different facets of reasoning is discussed. The idea is to explore what are rational behind developing reasoning skills in an individual. In this section the engineering employability skills is considered to be present in the individual having a high engineering aptitude. To explore engineering aptitude further a number of previously published works is discussed.

Next section will describe the methodology used to conduct this research, which include to description of descriptive research design, the explanation of sampling design employed, data collection and analysis methodology. The last section covers the result and discussion portion of the analysis obtained. This is followed by the conclusion comments on the result obtained through this study and the implication of the conclusion and scope for future work is also presented.

Literature Review: There has been substantial amount of work mainly in psychological literature about the nature and the content of reasoning. The literature on reasoning and critical thinking goes hand in hand and I explode extensively by academician and psychologist.

The literature on aptitude and more specifically on engineering aptitude are considered by most academicians as a part of reasoning skills. But there has been dearth of literature in which engineering aptitude has been considered as a separate construct. More specifically there are very less studies available that analyze the relationship between engineering aptitude and reasoning skills.

Reasoning Ability: Critical thinking and ability to analyze situation with reasonable logic are essential aspect that one should posses while performing a technical task. As Angelo[1] explained that

"Critical thinking does not simply develop as a result of maturation, but involves skills that are notoriously difficult to teach and learn, the problem as to how to raise students possible low critical thinking competency levels also deserves attention" (Angelo, 1995, p. 6).

Because reasoning skills does not improve automatically as the age progress it is more desirable to explore different facets of reasoning. Historically many psychologist and academician have studied and explore different aspect of reasoning skills. Initially they experimented on animals rather than human to investigate whether reasoning skill improve with maturation or not[2]. In one of his experiment he put a cat in a box having puzzle like directions. He repeated this act again and again and concluded that initially the movement of Cat was random and as the time progress the movement become more orderly but you cannot conclude this result to the theory of engineering.

Uri Zoller et.al[3] studied the desposition of eleventh grade student towards critical thinking. They concluded that there is a presence of baseline reference towards the deposition of critical thinking in the mind of eleventh grade students. Kyllonen P. and Christal R.[4] studied the relationship between reasoning ability and working memory capacity in four of these studies they concluded that there is a high correlation between general knowledge and reasoning ability of the individual.

Some psychologist think that reasoning still is important area to understand the conceptual formation in the mind of an individual, Kohler[5] took a cognitive perspective while explaining the problem solving behavior.

Engineering aptitude: The present undergrads, in an innovation upgraded condition, are expected that they would learn content at a quicker rate than any time in recent memory. While doing so they are expected to develop hard technical skills as well as soft people skill which are abilities important to

be fruitful in the working environment as discovered and communicated in their research by Hofstrand[6], the management of these skill is an driver to develop economy of any country and then by Shivpuri and Kim in 2004[7] assessed the skill gap that is prevalent for engineering graduate to become employable. Candy and Crebert[8] indicated the difficulty graduate face while transiting from academic environment to workplace. Martin et al[9] identified the skill set necessary for a graduate to excel in work place[10].

Methodology

The broad methodology adopted for the study is descriptive in nature. The study is conducted during the period of six month during which the data was collected from engineering student on their engineering aptitude and reasoning skills.

Objective of the study: The engineering aptitude can be thought of as the ability of engineering college student to grasp and apply engineering concepts. To identify the level of engineering aptitude it was necessary to measure the engineering aptitude of the engineering college students of Durg-Bhilai region. So first objective was - i. To measure the engineering aptitude of the student of engineering college of Durg-Bhilai region.

Since it was required to find the relation between reasoning ability of the student and it's engineering aptitude the second objective was - ii. To measure the reasoning ability of the engineering college students of Durg-Bhilai region.

Since a large proportion of engineering students were female it as required to identify that is there any difference between the engineering aptitude and reasoning ability of male and female students, this proportion gave rise to the next two objectives as – iii. To identify the difference in engineering aptitude of male and female engineering college student of Durg-Bhilai region. iv. To identify the difference in reasoning ability of male and female engineering college students of Durg-Bhilai region.
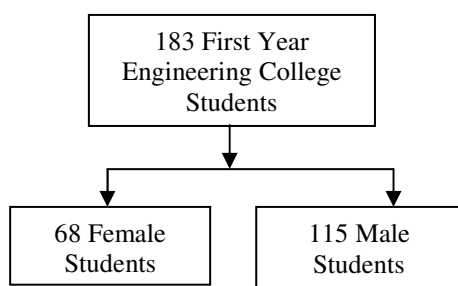
The primary objective of the study was to identify the relationship between engineering aptitude and reasoning ability of engineering student for this it was also necessary to investigate that if there is a relationship, than, does it hold good for male and female separately. So the next three objective focus on this investigation as – v. To discover the relationship between reasoning ability and engineering aptitude of engineering college student of Durg-Bhilai region. vi. To discover the relationship between reasoning ability and engineering aptitude of Male engineering college student of Durg-Bhilai region. vii. To discover the relationship between reasoning ability and engineering aptitude of female engineering college student of Durg-Bhilai region.

Hypotheses: Hypotheses are assumption about the population of interest based on the objective of the study. Since it as

required to investigate that do the engineering aptitude as well as the reasoning ability of male and female engineering student differ in magnitude the first two hypotheses were required to be checked to fulfill these objectives. i. H_1: The engineering aptitude of male and female engineering students of engineering Colleges of Durg-Bhilai region do not differ. ii. H_2: The reasoning ability of male and female engineering students of engineering colleges of Durg-Bhilai region do not differ.

The relationship between reasoning ability and engineering aptitude were assumed to be non existing and to investigate it following Hypothesis were formed firstly to check for whole population and then to check for sub population of male and female engineering students. iii. H_3: There is no relationship between engineering aptitude and reasoning ability of engineering students of engineering colleges of Durg-Bhilai region. iv. H_4: There is no relationship between engineering aptitude and reasoning ability of female engineering students of engineering colleges of Durg-Bhilai Region. v. H_5: There is no relationship between engineering aptitude and reasoning ability of male engineering students of engineering colleges of Durg-Bhilai region.

Sampling design: In this study probability sampling design was used. The sampling design was mixed sampling, consisting of stratified sampling at first stage and then using simple probability random sampling to select sample element from each strata. The sampling frame was the roll list of enrolled student studying in first year of engineering course. First stage strata comprises of male and female student in the total sample. At the last stage random sampling was used to identify the sample elements from each sub strata. The breakup of the sample items according to gender, will be as follows –

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┌─────────────────────┐
│   183 First Year    │
│ Engineering College │
│      Students       │
└─────────────────────┘
       │       │
┌──────────┐ ┌──────────┐
│68 Female │ │115 Male  │
│ Students │ │ Students │
└──────────┘ └──────────┘
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Figure-1: Breakup of sample according to gender.

The size of various sample units was decided on the basis of their respective share in population. On analyzing the population it is seen that in bachelor of engineering course the male are having much greater enrolment as compared to female. Total number of Technical Institution in Chattisgarh state is 48 and if we include the institution outside the purview of Chattisgarh Swami Vivekanand Technical University (CSVTU) then there are 80 Institution. Out of these institution 22 are located in Bhilai-Durg area. The total seats offered to take admission in first year of course of engineering is 16,500. The population of engineering student studying in first year of

Bachelor of engineering course in Bhilai-Durg 4500 under the purview of CSVTU. As the scope of study covered Durg-Bhilai region the appropriate sample size was determined accordingly, as 200 covering approximately 4.5% of the population.

Data Collection: After zeroing out the ideal sample size, the roll list of the student in first year of B.E. courses as obtained to act as a sampling frame. Initially, the first stage stratified sampling was done to segregate the sampling frame into two parts first consisting of male engineering college students and second strata consisting of female engineering college students. Then in second stage the simple probability random sampling techniques was applied to identify 130 male and 70 female sample elements. Most of the sample elements concentrated in five colleges of Durg city area, few element were from remote area or from relatively new colleges, which were dropped and same no of elements were added from city area again following random sampling. It was not possible to collect data from 15 male and 2 female sample elements as they might have dropped out from the course. This has reduced the sample size to 183 with 115 male and 68 female elements.

Results and discussion

Checking the Normality assumption: In order to perform statistical inferential analysis using parametric tests, the critical assumption is that the population follows the normal distribution. While collecting data from sample the variable reasoning aptitude and engineering aptitude of engineering graduate students were measured. The sampling technique adopted was stratified probability sampling, where the strata were male and female engineering student. The normality assumption was checked in the two strata, by plotting the Histogram and conducting Shapiroi-Wilk test for the two variables reasoning ability and engineering aptitude, so as to confirm the applicability of inferential statistical technique. Shaipro-Wilk test result confirms the approximate normal data for reasoning ability and engineering aptitude of both of the groups of male and female engineering student.

Table-1: Tests of normality.

Variable	Gender of Engineering Students	Shapiro-Wilk		
		Statistic	Df	Sig
Reasoning Ability	Female	.985	68	.585
	Male	.978	115	.058
Engineering Aptitude	Female	.974	68	.167
	Male	.974	115	.025

The Normality assumption is further strengthened by referring the approximate bell shaped curve drawn on Histograms of both of the variable for both of the groups of male and female engineering student.
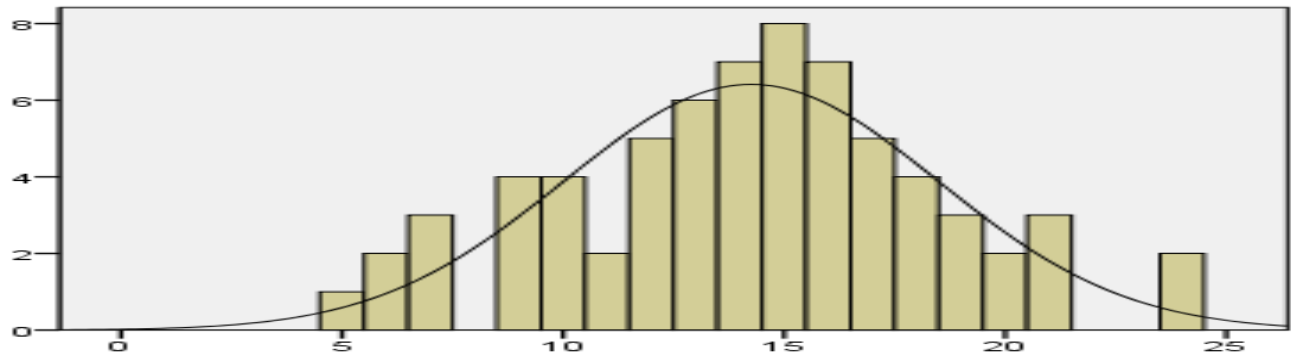
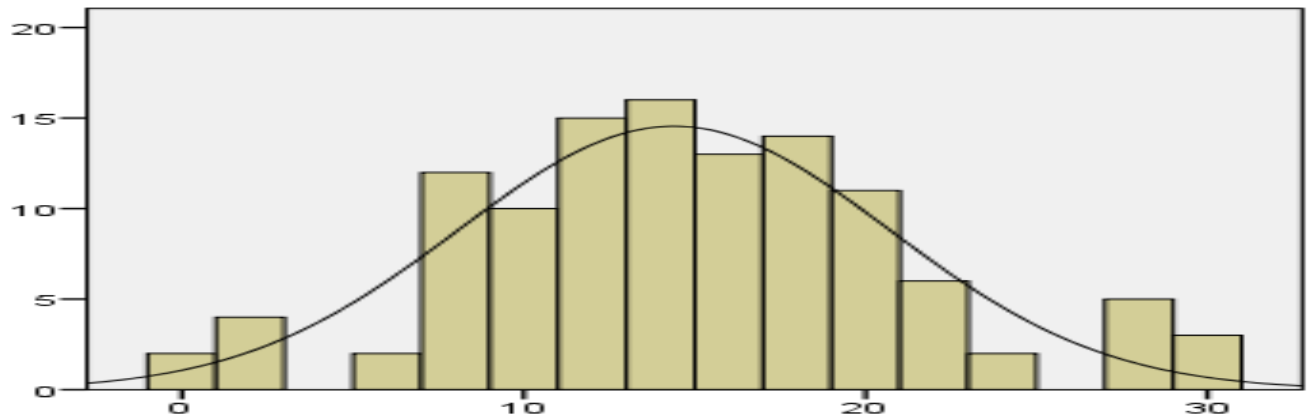**Figure-2:** Frequency Histogram Female Frequency/ Reasoning Ability.

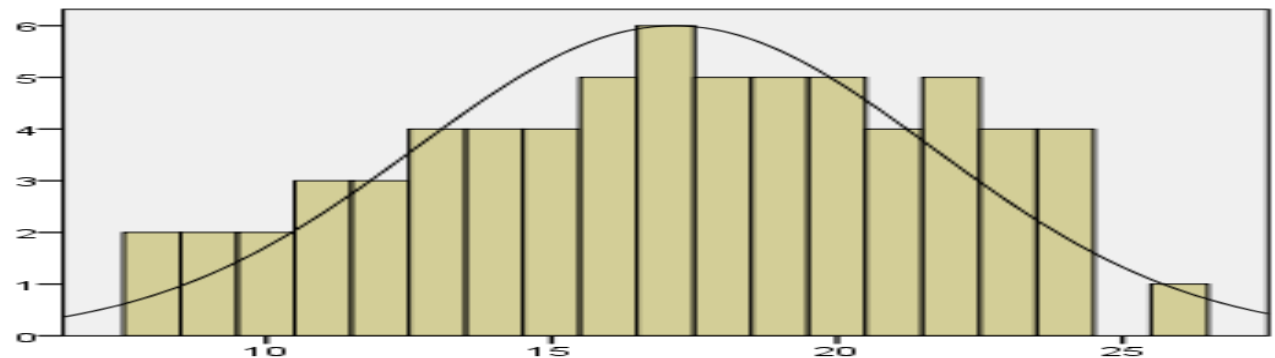**Figure-3:** Frequency Histogram Male Frequency/ Reasoning Ability.

Figure-4: Frequency Histogram Female Frequency/ Engineering Aptitude.
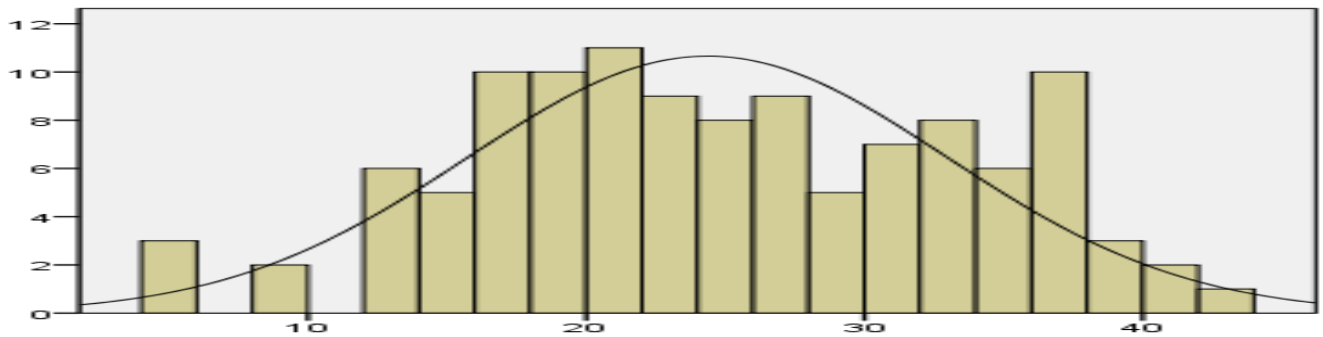
Figure-5: Frequency Histogram Male Frequency/ Engineering Aptitude.

Descriptive statistics: The descriptive statistics shows that the reasoning ability score of engineering college student range from minimum value of 0 to 30 with the mean score of 14.34 with the standard deviation of 5.612. Whereas the engineering aptitude have a minimum score of 5 to the maximum of 42 and it has the mean score of 21.68 with the standard deviation of 8.13.

While observing the descriptive statistics gender wise it has been found the female engineering student have a mean score of 14.25 with a standard deviation of 4.2 for the reasoning aptitude female have mean score of 17.15 with the standard deviation of 4.52 for the engineering aptitude score. The descriptive statistics of male student shows that for the reasoning aptitude score they have a mean value of approximately 14.4 with a bit higher standard deviation of 6.3 as compared to female group for the same variable. In the case of engineering aptitude male students have mean score of 24.36 with a high standard deviation of 8.60.

The Research Question: The first two research question were answered by referring the descriptive statistics of male and female group, and students as a whole. While analyzing the descriptive statistics it was confirmed that there was not much of the difference in the mean score of male and female engineering student score of reasoning ability where as in measuring engineering aptitude the mean score obtained by

males is much higher as that obtained by female. This conclusion also directed us to investigate our 3rd and 4th research question, to investigate whether significant difference exist between male and female engineering student regarding their reasoning and engineering aptitude score. On conducting independent sample 't' test between male and female students on their score of reasoning ability and engineering aptitude, it was found that there was no significant difference that exist between reasoning ability of male and female student. But there was a significant difference between engineering aptitude score of male and female engineering student students. Hence out of the Hypothesis, H_1 was accepted and H_2 was rejected.

Correlation analysis: In order to investigate the research question 5, 6 and 7 the correlation analysis is been conducted between reasoning ability score and engineering aptitude score firstly for all engineering students and then by grouping students gender wise. The result of the analysis are given in the Table-5.

There are indications that there is a strong positive correlation r=0.553 between reasoning ability score and engineering aptitude score of the engineering student students thesis correlation was found significant at 0.01 level.

On splitting the dataset between groups the correlation analysis was done again and the result are given in the Table-6.

Table-2: Descriptive statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
Reasoning Ability	183	0	30	14.34	5.612
Engineering Aptitude	183	5	42	21.68	8.133

Table-3: Descriptive statistics (Gender Wise).

Gender		N	Minimum	Maximum	Mean	Std. Deviation
Female	Reasoning Aptitude	68	5	24	14.25	4.2
	Engineering Aptitude	68	8	26	17.15	4.5
	Valid N (list wise)	68				
Male	Reasoning Aptitude	115	0	30	14.4	6.3
	Engineering Aptitude	115	5	42	24.36	8.6
	Valid N (list wise)	115				

Table-4: Independent Samples Test.

	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Reasoning Ability	.181	178.070	.857	.141	.780
Engineering Aptitude	6.399	181	.000	7.209	1.127

The result shows that there is a strong significant correlation between reasoning ability score and engineering aptitude score of both of the groups of male and female students. The correlation is strong and positive and it is even stronger for female engineering students with r=0.70. For male engineering students r = 0.59.

Predicting engineering aptitude on the basis of reasoning ability score: During correlation analysis it was observed that

there was high degree of significant correlation between reasoning ability score and engineering aptitude score of engineering student. It was then desired to investigate that to what extent we can predict the engineering aptitude of student on the basis of reasoning ability score of students. For this a regression analysis was conducted where reasoning ability score was taken as predictor variable and engineering aptitude score was taken as a dependent variable. The result is given in the table-8.

Table-5: Correlations Analysis (Whole Group).

Correlations Analysis		Reasoning Ability	Engineering Aptitude
Reasoning Ability	Pearson Correlation sig.	1	.553[**]
Engineering Aptitude	Pearson Correlation sig.	.553[**]	1

**. Correlation is significant at the 0.01 level (2-tailed).

Table-6: Correlations Analysis for Female Group.

Correlations Analysis for Female Group		Reasoning Ability	Engineering Aptitude
Reasoning Ability	Pearson Correlation sig.	1	0.703**
Engineering Aptitude	Pearson Correlation sig.	0.703**	1

**Correlation is significant at the 0.01 level (2-tailed).

Table-7: Correlations Analysis for Male Group.

Correlations Analysis for Male Group		Reasoning Ability	Engineering Aptitude
Reasoning Ability	Pearson Correlation sig.	1	0.590[**]
Engineering Aptitude	Pearson Correlation sig.	.590[**]	1

**. Correlation is significant at the 0.01 level (2-tailed).

Table-8: Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.553[a]	.306	.302	6.794

a. Prictor: (Constant), Reasoning Ability.

Table-9: Anova.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3682.879	1	3682.879	79.784	.000[b]
	Residual	8355.099	181	46.161		
	Total	12037.978	182			

a. Dependent Variable: Engineering Aptitude.

Table-10: Coefficients[a].

Model		Unstandardized Coefficients		T	Sig.
		B	Std. Error		
1	Constant	10.185	1.381	7.374	.000
	Reasoning Ability	.801	.090	8.932	.000

a. Dependent Variable: Engineering Aptitude.

It was observed from the analysis that reasoning ability score was able to explain 30% of variance in the engineering aptitude of engineering student students. The result of Anova analysis indicates that the regression coefficient has explain significantly the variation in the response variable. The table of coefficient was able to determine the Model to predict engineering aptitude of students based on the reasoning ability score.

Engineering Aptitude = 10.18 + 0.8 * Reasoning Ability.

The coefficient of model the constant term and thee coefficient of reasoning ability was found to be significant.

Conclusion

There has been a through debate in improving the quality of engineering who graduate from different engineering colleges so that they become job ready by the time they graduate. One way to do this is to select those students as a future engineering graduate who have a higher aptitude of engineering. To achieve this purpose the regular exam conducted by various state testing agencies, to select student Engineering Student, should undergo a major reformation.

The importance of reasoning ability has been widely accepted as a parameter to improve professional efficiency. The research conducted on engineering student students shows that the male and female engineering student do not differ in reasoning ability but they do differ in their engineering aptitude level. It has also been concluded there seem to be high and significant correlation between engineering aptitude and reasoning ability of these students. Owing to this conclusion since direct questions of engineering aptitude could not be asked in the entrance examination of engineering student it seems if the emphasis is given to the reasoning ability question in the entrance then there are higher chances that we will be able to select engineering student students who might develop higher aptitude for engineering during their training.

It can also be concluded that since the reasoning ability score was able to explain approximately 45 % of variation in the engineering aptitude score the weight age of reasoning ability in the entrance test should be somewhere close to 45 % of the total weight age.

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