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Effectiveness of Formal Logic Course on the Reasoning Skills of Students in Nizwa College of Technology, Oman

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Abstract
The study of formal logic helps to improve the process of thinking and tries to refine and improve the thinking ability. The objectives of this study are to know the effectiveness of formal logic course and to determine the critical thinking variables that are effective and that are ineffective. A sample of 214 students is selected from all the three departments Engineering, Information Technology and Business department from Nizwa College of Technology, Sultanate of Oman. The analysis revealed that there is no significant relationship between critical thinking variables and formal logic course. It is found that deductive and interpretation skills of the students have increased after the posttest. At the same time, inference skills, assumptions and arguments decreased after the posttest. Assumption skill is found to be the most favourable critical thinking variable.
Keywords: Inference, Assumptions, Deductions, Interpretations, Arguments

Introduction

Critical Thinking is the ability to analyze the way of thinking and present evidence for ideas. It helps in decision making process and to solve problems. It is based on evidence and logical reasoning. It requires evaluating and improving our own thought processes. Critical thinking is self-directed, self-disciplined, self-monitored, and self-corrective thinking. It is a valuable skill for students to learn. Critical thinking skills teach a variety of skills that can be applied to any situation in life that calls for reflection, analysis and planning. The ability to think clearly and rationally is important in our daily life. It entails effective communication and problem solving abilities.

Scope of the study

Many researchers stated that critical thinking is poor in most educated adults and children. Halpern (1998) concluded that adults fail to think critically in many situations. Kennedy et al., (1991) and Van Gelder (2005) also concluded that many adults lack basic reasoning skills. One should not expect to see dramatic improvements in critical thinking over time due to instructional interventions. Improvements in critical thinking are slow and incremental (Halpern, 1998). Paul (1992) argues that typical school instruction does not encourage the development of higher-order thinking skills like critical thinking. Researchers are optimistic about the capacity of humans to become critical thinkers with appropriate instruction. Kennedy et al. (1991) suggested that students of all intellectual ability levels can benefit from critical thinking instruction. The Ministry of Manpower in Oman has decided to remove formal logic course from their curriculum in 2015, which applies to all seven colleges of Technology. In this context, a study is needed to identify the significance of the course. Hence the study helps to know whether formal logic course helps to improve critical thinking skills of the students. No attempt is made by researchers to address this issue. Hence, this study is significant.

Literature review

Students often face difficulties due to their inability to see the multiple interpretations of the same data. Understanding the different stages may help teachers consider the best ways of presenting material in order to help students make the transition from one stage to the next (Allen, 1981). Although most people recognize the need for critical thinking skills, the teaching of those skills is often different from content. As a result, critical thinking programs are often unsuccessful. A better program would integrate the application of critical thinking skills into the learning of content (Kathryn, 1988). Gleichsner (1994) presents an assignment of writing a critical review of a refereed journal article as a way to develop critical thinking in the classroom. Patricia et al. (1990) used multiple measures of critical thinking to find out whether critical thinking ability varies by graduate/undergraduates, gender, discipline, and academic ability. They found that graduate students scored higher than undergraduates. The problem with current instruction in critical thinking is that it separates factual content from thinking. Current approaches may deal with formal/informal logic issues, but shows examples of logic fallacies, rather than the thought processes (Joe, 1998). John (1996) stated that critical thinking includes certain aspects of problem solving and various skills. Critical thinking can be taught using drills and practice. Students must be motivated to use their critical thinking skills. Nelson (1994) introduces key aspects of the pedagogy of critical thinking and their relationships with collaborative learning. He suggested that it is important to learn how to explain why incorrect responses occur, in addition to providing the disciplinary expectations of a

subject and included in-class exercises to accomplish this level of critical thinking. Olson (1985) connected writing and thinking processes and presented a lesson plan to be used at grade-school level that encourages students to use all levels of thinking (knowledge, comprehension, application, analysis, synthesis, evaluation) and all parts of the writing process (prewriting, precomposing, writing, sharing, revising, editing, evaluation).

Objectives of the study

1. To know the effectiveness of formal logic course on critical thinking skills of students.
2. To determine the critical thinking variables that are effective and that are ineffective.
3. To identify the favourable critical thinking variable.
4. To make decision whether formal logic course should be continued in the curriculum.

Research design

The sampling frame of the study was formal logic students of Nizwa College of technology. To study the effectiveness of formal logic course a pretest and posttest was conducted on the students who studied formal logic course. A sample of 214 students was selected from all the three departments Engineering, Information Technology and Business students. The study period was Semester 2, from January 2015 to May 2015. The pretest was done in the first week of January 2015 and the posttest was administered in the last week of May 2015. Stratified random sampling was adopted to collect the samples. Watson Glacier critical thinking model was adopted and a structured questionnaire was used for data collection. The same instrument was administered before the test and after the test to the same students. Students were instructed to complete the questionnaire within 30 minutes in a relaxed atmosphere. The study measures the critical thinking variables like inference, assumption, deduction, interpretation and arguments. Paired t-test and coefficient of variation tools are used for analysis.

Analysis of the study

1. Inference

An inference is a conclusion that a person can draw from certain observed or supposed facts. After each statement of fact students find several possible inferences i.e., conclusions are drawn from the stated facts. The test examines each inference separately, and makes a decision as to its degree of truth or falsity.

Table 1.1 Paired Samples Statistics (Inference)

		Mean	N	Std. Deviation	Std. Error Mean
	Before	1.03	214	.830	.057
	After	.99	214	.864	.059

The mean inference skill of the students before learning formal logic course was 1.03 with a standard deviation of 0.83. The inference skill of the student after studying formal logic course is 0.99 with a standard deviation of 0.86. The mean value shows that the inference skills have reduced after learning formal logic course. Hence the following hypothesis is tested.

Ho: There is no difference in inference skills after studying Formal Logic course.

H1: There is a difference in inference skills after studying Formal Logic course

From table 1.2, it is observed that the t-statistic, t = 0.558 and p = 0.57.This shows there is a large probability of this result occurring by chance, under the null hypothesis of no difference. The null hypothesis is accepted, since p > 0.05. There is no strong evidence (t = 0.558, p =0.058) that learning formal logic course has improved the inference skills of the students. In this data set, the inference skill is decreased, on average by 0.047 points.

Table 1.2. Paired Samples Test (Inference)

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Before - After	.047	1.225	.084	-.118	.212	.558	213	.577

The paired samples correlation adds the information that before and after inference skills are significantly negatively correlated (r = -0.045, p = 0.51). At 95% confidence level the true value of difference lies between -0.1 to 0.21. This confirms that the difference in inference skills is statistically insignificant. Thus it is concluded that the decrease in inference skills is not due to the impact of formal logic course.

2. Assumptions

An assumption is something presupposed or taken for granted. Each statement is followed by several proposed assumptions. Students should decide for each assumption whether it can be taken for granted, justifiably or not.

Table 2.1 Paired Samples Statistics (Assumptions)					
		Mean	N	Std. Deviation	Std. Error Mean
	Before	2.85	214	.793	.054
	After	2.70	214	.953	.065

The mean assumption skill of the students before learning formal logic course was 2.85 with a standard deviation of 0.79. The assumption skill of the student after studying formal logic course is 2.70 with a standard deviation of 0.95. The mean value shows that the assumption skills reduced after learning formal logic course. Hence the following hypothesis is tested.

Ho: There is no difference in assumption skills after studying Formal Logic course.

H1: There is a difference in assumption skills after studying Formal Logic course

From table 2.2, it is observed that the t-statistic, t = 1.86 and p = 0.064. This shows there is a large probability of this result occurring by chance, under the null hypothesis of no difference. The null hypothesis is accepted, since p > 0.05. There is no strong evidence (t = 1.86, p =0.064) that learning formal logic course has improved the assumption skills of the students. In this data set, the assumption skill is decreased, on average by 0.150 points.

Table 2.2 Paired Samples Test (Assumptions)								
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	Sig. (2-tailed)
Before – After	.150	1.173	.080	-.009	.308	1.864	213	.064

The paired samples correlation adds the information that before and after assumption skills are significantly positively correlated (r = 0.106, p = 0.12). At 95% confidence level the true value of difference lies between -0.009 to 0.308. This confirms that the difference in assumption skills is statistically insignificant. Thus it is concluded that the decrease in assumption skills is not due to the impact of formal logic course.

3. Deductions

An exercise consisting of several statements followed by several suggested conclusions is given. The statements in each exercise are considered as true without exception. The students should judge whether each conclusion necessarily follows the statement.

Table 3.1 Paired Samples Statistics (Deductions)					
		Mean	N	Std. Deviation	Std. Error Mean
	Before	1.70	214	.813	.056
	After	1.78	214	.791	.054

It is clear from table 3.1 that the mean deduction skill of the students before learning formal logic course was 1.70 with a standard deviation of 0.81. The deduction skill of the student after studying formal logic course is 1.78 with a standard deviation of 0.79. The mean value shows that the deduction skills increased after learning formal logic course. Hence, the following hypothesis is tested.

Ho: There is no difference in deduction skills after studying Formal Logic course.

H1: There is a difference in deduction skills after studying Formal Logic course.

From table 3.2, it is observed that the t-statistic, t = -0.970 and p = 0.33. This shows there is a large probability of this result occurring by chance, under the null hypothesis of no difference. The null hypothesis is accepted, since p > 0.05. There is no strong evidence (t = 0.97, p = 0.33) that learning formal logic course has improved the deduction skills of the students. In this data set, the deduction skill is increased, on average by 0.075 points.

Table 3.2 Paired Samples Test (Deductions)								
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Before – After	-.075	1.128	.077	-.227	.077	-.970	213	.333

The paired samples correlation adds the information that before and after deduction skills are significantly positively correlated (r = 0.012, p = 0.86). At 95% confidence level the true value of difference lies between -0.227 to 0.077. This confirms that the difference in deduction skills is statistically insignificant. Thus it is concluded that the increase in deduction skills is not due to the impact of formal logic course.

4. Interpretations

The problem is to judge whether or not each of the proposed conclusions logically follows beyond a reasonable doubt from the information given.

Table 4.1 Paired Samples Statistics (Interpretations)					
		Mean	N	Std. Deviation	Std. Error Mean
	Before	1.34	214	.908	.062
	After	1.42	214	1.002	.069

Table 4.1 shows that the mean interpretation skill of the students before learning formal logic course was 1.34 with a standard deviation of 0.908. The interpretation skill of the student after studying formal logic course is 1.42 with a standard deviation of 1.002. The mean value shows that the interpretation skills increased after learning formal logic course. Hence the following hypothesis is tested.

Ho: There is no difference in interpretation skills after studying Formal Logic course.

H1: There is a difference in interpretation skills after studying Formal Logic course

From table 4.2, it is observed that the t-statistic, t = -0.880 and p = 0.38. This shows there is a large probability of this result occurring by chance, under the null hypothesis of no difference. The null hypothesis is accepted, since p > 0.05. There is no strong evidence (t = -0.88, p = 0.38) that learning formal logic course has improved the interpretation skills of the students. In this data set, the interpretation skill is increased, on average by 0.079 points.

Table 4.2 Paired Samples Test (Interpretations)								
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Before – After	-.079	1.321	.090	-.257	.099	-.880	213	.380

The paired samples correlation adds the information that before and after interpretation skills are significantly positively correlated (r = 0.047, p = 0.49). At 95% confidence level the true value of difference lies between -0.257 to 0.099. This confirms that the difference in interpretation skills is statistically insignificant. Thus, it is concluded that the increase in interpretation skills is not due to the impact of formal logic course.

5. Arguments

In making decisions about important questions, it is desirable to be able to distinguish between arguments that are strong and arguments that are weak. For an argument to be strong, it must be both important and directly related to the question. An argument is weak if it is not directly related to the question.

Table 5.1 Paired Samples Statistics (Arguments)					
		Mean	N	Std. Deviation	Std. Error Mean
	Before	1.67	214	.838	.057
	After	1.65	214	.823	.056

Table 5.1 shows that the mean argument skill of the students before learning formal logic course was 1.67 with a standard deviation of 0.838. The interpretation skill of the student after studying formal logic course is 1.65 with a standard deviation of 0.82. The mean value shows that the argument skills decreased after learning formal logic course. Hence, the following hypothesis is tested.

Ho: There is no difference in argument skills after studying Formal Logic course.

H1: There is a difference in argument skills after studying Formal Logic course

From table 5.2, it is observed that the t-statistic, t = 0.179 and p = 0.85. This shows there is a large probability of this result occurring by chance, under the null hypothesis of no difference. The null hypothesis is accepted, since p > 0.05. There is no strong evidence (t = 0.179, p = 0.85) that learning formal logic course has improved the argument skills of the students. In this data set, the argument skill is increased, on average by 0.014 points.

Table 5.2 Paired Samples Test (Arguments)								
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Before - After	.014	1.148	.079	-.141	.169	.179	213	.858

The paired samples correlation adds the information that before and after arguments skills are significantly positively correlated (r = 0.044, p = 0.52). At 95% confidence level the true value of difference lies between -1.41 to 0.169. This confirms that the difference in arguments skills is statistically insignificant. Thus it is concluded that the increase in arguments skills is not due to the impact of formal logic course.

6. Coefficient of Variation of Critical skills

Table 6.1 Coefficient of variation

Critical thinking variables	Before mean	SD Before	CV	After mean	SD After	CV
Inference	1.03	0.83	80.5%	0.99	0.86	86.86%
Assumptions	2.85	0.79	27.71%	2.70	0.95	35.18%
Deductions	1.70	0.81	47.64%	1.78	0.79	44.38%
Interpretations	1.34	0.90	67.16%	1.42	1	70.42%
Arguments	1.67	0.83	49.70%	1.65	0.82	49.69%

Table 6.1 reveals that the mean value of Assumption is highest and it was 2.85 before studying formal logic and after learning the course the mean was found to be 2.70. Comparing the means of critical thinking variables, Assumptions and Deductions skills have increased after the study. But the mean of other critical variables namely Inference, Interpretation skills and Arguments decreased after this study. The spread is high from the mean for Inference skills of the students. Comparing all the critical thinking skills, the spread is less for Assumptions skills and it is considered as a favourable critical thinking variable due the study of formal logic course.

Findings of the study

1. It is proved through t-test that there is no significant relationship between critical thinking variables and formal logic course. It is proved that formal logic course is ineffective and has not contributed in developing critical thinking skills of the students.
2. Comparing the pretest and posttest means of the critical thinking variables, it is found that deductive and interpretation skills of the students have increased after the posttest. At the same time, inference skills, assumptions and arguments decreased after the posttest.
3. Assumption skill is found to be the most favourable critical thinking variable as the spread from the mean value is less (CV = 35.18). Hence it is concluded that students could improve their assumption skills by studying formal logic course.
4. It is proved through hypothesis testing that the present formal logic outcomes are found to be ineffective and hence could not contribute to student's critical thinking skills.

Recommendations

1. The outcomes of the present course should be revised to improve critical thinking skills.
2. The course contents should be revised with more of activities and assignments.
3. Critical thinking variables should be incorporated in each course and therefore students can apply these skills in each course.
4. Apart from the existing curriculum, students should be given practical training on critical thinking.

Conclusion

The results of the pretest and posttest evaluation of formal logic course indicate to be sensitive enough to detect a positive effect on student's critical thinking and problem solving skills. The findings suggest that formal logic is important to promote critical thinking and problem solving skills. Critical thinking is not solely an academic skill, though it is certainly valued in academicia. Critical thinking emphasize on day-to-day value, able to control our own lives, help our family and friends, and participate as thoughtful citizens. It is also highly valued by employers who look for their employees to do better.

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