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Divergence of Scientific Heuristic Method and Direct Algebraic Instruction

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Abstract

This is an experimental study, made used of the non-randomized experimental and control groups, pretest-posttest designs. The experimental and control groups were two separate intact classes in Algebra. For a period of twelve sessions, the experimental group was subjected to the scientific heuristic method, but the control group instead was given direct instruction on selected topics of Algebra. Using a non-parametric statistical test, particularly the Wilcoxon Rank-Sum test, results showed that students in the experimental group performed significantly better than the control group in the post-test. On the other hand, the Fisher's Exact Probability Test yielded very statistically significant different proportions in the post-test scores between the experimental and control group. It is highly recommended that integration of scientific heuristic method in teaching mathematics is essential.

Keywords: scientific heuristic, direct instruction

1. Introduction

Teaching has come a long way in establishing itself as a profession. Teachers are internationally being recognized as professionals in their own respect. Like other professionals, the status of teaching hinges in large measure the professionalism of its members. Hence, for society to recognize and acknowledge the significance and dignity of the teaching profession, teachers have to continually improve the teaching competencies with which to guide student learning.

The center of any educative process is the learner. Without the learner, there would be no need for teaching. The system of education or schooling is a macro-view of the learning process. Education is a means of transmitting the values and knowledge necessary for society's continuation. On the other hand, the teaching-learning process which occurs in the classroom setting is a micro-view of the educational process. There are inherently several variables worth considering when examining the teaching-learning process. Moreover, the quality of instruction largely determines the probable outcome of the teaching-learning process. The teacher is a great factor in the teaching-learning process and therefore should have a thorough knowledge and understanding of the students which serves as essential starting point in harnessing their potentialities and achieving optimum development of their own endowments. The goal of Mathematics education is to encourage the use of precise and accurate thinking to solve problems. Intuitive reasoning is used as a guide to rigorous thinking.

The study outlines two distinct methods of teaching mathematics - the scientific heuristic and direct instruction. Under the direct instruction, mathematics often appears to students as a finished body of knowledge accumulated by creative individuals known as mathematicians and presented as such by teachers who have mastered the body of knowledge and who in turn try to teach it to their students in this finished form. On the other hand, Scientific Heuristic Methods are concerned with those of controlled discoveries – "discovery" because a great deal of the learning of each student arises from his reactions to situations "scientific" because the intent always is to closely scrutinize all assumptions made with amendment as further realities are revealed. The teacher who utilizes scientific heuristic method sees his role as one of facilitating learning. The teacher believes in creating an environment whereby the students can inquire for themselves. It creates situations where free discussion takes place among the students and plays the role of a participant and guide rather than as the authority for the discussion.

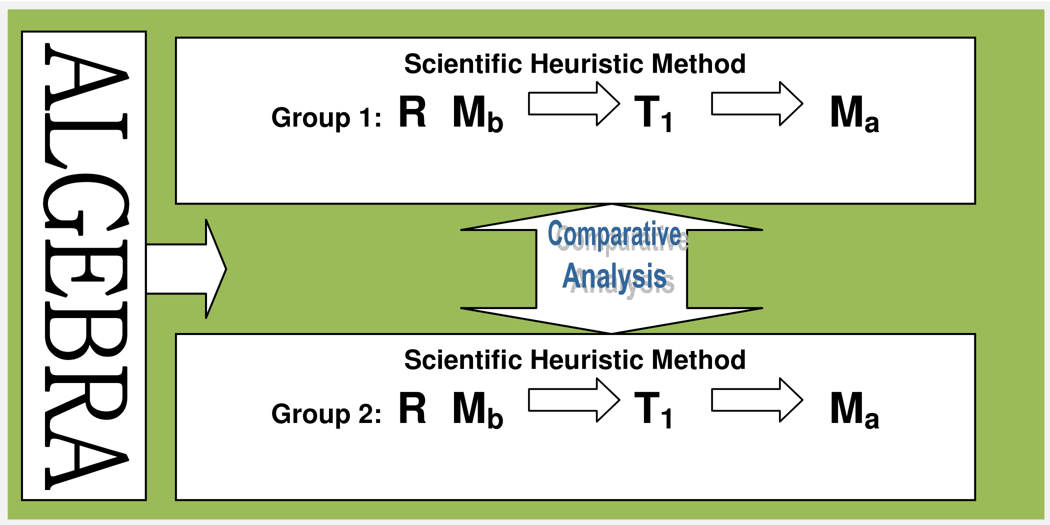
Scientific Heuristic Approach was constructed in such a way as to facilitate the most efficient method of a user to acquire a new body of knowledge, learn new skills or be challenged on existing attitudes. It has concretized pretty well the principle of individual differences allowing each student to proceed at his own pace. The Scientific Heuristic method also attempts to bridge the gap between the felt need and the course objective of equipping the students with mathematical tools needed in skills development. With the desire to improve the quality of mathematics education in AMAIUB, the researcher attempted to compare the scientific heuristic method and direct instruction in teaching selected topics of college algebra.

This study attempts to investigate a "Scientific Heuristic Approach" to the teaching of selected topics of Algebra as compared to a more traditional approach, and to assess as a result, the effect on their achievement in Algebra.

Two intact College Algebra classes were utilized as subjects of the study. The contents of the course taught during the sessions were: real numbers, sets, linear equations in one variable, factoring of quadratic polynomials, inequalities, and operations with rational algebraic expressions. The study was limited to AMA International University - Bahrain freshmen college algebra students and did not represent the entire AMA Educational System.

1.1 Conceptual Framework

The Pretest – Posttest Control Group Design was used in this study. It was depicted schematically by the following figures:



The **R** in the model indicates that the two groups were assigned randomly, $\mathbf{M_b}$ corresponds to measurement before the experiment (pretest), **T1** and $\mathbf{T_2}$ refer to the two different teaching methods and $\mathbf{M_a}$ signifies measurement after the teaching session (posttest). This study rests on the concept that the performance of freshmen college algebra students can be affected by the manner of application activity afforded to the learners after the lesson in mathematics had been conducted. Scientific heuristic learning techniques was used as a treatment in the experimental group and traditional learning technique will be used in the control group. In mathematics, the time for students to try out what they have learned in the day's lesson is very important. It is on this part of the lesson where the students apply what they had learned and this can be a factor that will make the lesson interesting and enjoyable to them. It is necessary that students should be provided with appropriate opportunities to practice and apply the new content presented. In the scientific heuristic learning, practice task will be given after the lesson. In the traditional learning, after the teacher has conducted the lesson, the students will be given practice task to apply the concepts the teacher had taught them. Results of the evaluation will be analyzed to determine whether such activities could improve the students' performance in the evaluation. Thus, the improvements of the students' performance in mathematics were determined through the result of the evaluation.

2. Research Design

A quasi – experimental design was utilized with an experimental group of students which was taught by the researcher using controlled discovery techniques. The major focus of this method was the subordination of teaching to learning (also called the scientific heuristic approach). The control group was taught by the researcher using more standard teaching techniques involving a teacher-centered classroom climate. The contents of the course taught during the sessions were: real numbers, sets, linear equations in one variable, factoring of quadratic polynomials, inequalities, and operations with rational algebraic expressions. The Pretest – Posttest Control Group Design was used in this study. It depicts schematically by the following figures:

Group 1: $\mathbf{R}\ \mathbf{M_b} \Rightarrow \mathbf{T_1} \Rightarrow \mathbf{M_a}$

Group 2: $\mathbf{R}\ \mathbf{M_b} \Rightarrow \mathbf{T_2} \Rightarrow \mathbf{M_a}$

The **R** in the model indicates that the two groups were assigned randomly, $\mathbf{M_b}$ corresponds to measurement before the experiment (pretest), $\mathbf{T_1}$ and $\mathbf{T_2}$ refer to the two different teaching methods and $\mathbf{M_a}$ signifies measurement after the teaching session (posttest).

The respondents of this study were the identified two intact College Algebra classes. The group assignment was selected through a toss coin. The pertinent data needed for the study was collected with the use of the following data-gathering instruments. Appropriate achievement test.

After the identification of respondents, the researcher conducted the experiment proper and personally administers the sets of questionnaires. In the experiment proper, the two groups were taught separately, meeting three hours weekly for a four-week period. One class taught using scientific heuristic method, the other class, was taught traditionally. Appropriate achievement test was administered to both classes before and after the session. The data gathered was tabulated, computed and interpreted.

2.1 Statistical Treatment of Data

Descriptive statistics such as the mean and standard deviation was used to describe the level of performance of the respondents in College Algebra. Due to discrepancy in sample size, a non-parametric statistical test particularly the Wilcoxon Rank-Sum test was used to test the difference in the level of performance in College Algebra between the control and experimental groups.

On the other hand, the Fisher's Exact Probability Test was used to find the difference in the proportion of passers in College Algebra between the control and experimental groups. This test is appropriate for two independent samples where the data are nominally casted in a 2x2 table. The null hypotheses were tested at the 0.05 level of significance.

3. Results and Discussion

Table 1. Mean Scores in College Algebra between the Control and Experimental Groups

DEPENDENT MEASURE	Control Group			Experimental Group	
	MEAN	S.D.		MEAN	S.D.
Pre-test	8.33	1.63		8.12	1.46
Post-test	16.33	2.73		22.25	2.19

The table presents the data on the level of performance of the two groups of respondents in CollegeAlgebra. Despite the difference in sample size, the distribution of the two sets of data was generally comparable as indicated by the small discrepancies between the standard deviations. It can be observed from Table 1 that the mean scores in College Algebra exhibited by both group of students on the pre-test indicator of the dependent variable were generally below average, the results indicated that the students generally below average in terms of mathematical skills and competencies in the said subject before the conduct of the experiment.

The same Table shows that the control group exhibited better mean scores in College Algebra pre-test than the experimental group. However, after the experiment proper the experimental group exhibited better mean scores in College Algebra post-test than the control group. The results of the data analysis revealed that the performance of the students in College Algebra specifically in the experimental group could be attributed largely in the scientific heuristic methods of teaching mathematics. The findings supported (Pescuela, 2006; Tiong, 2006; Foong, 2006; Tiong, Hedberg, & Lioe, 2005), results, that students who were exposed to heuristic approach performed significantly better both in the post-experiment and pre-post experiments than the students who were exposed to the algebraic method of teaching. However, the result failed to confirm Alvaro's (1973) findings, that after the experimental teaching of heuristic mathematics, the traditional class achieved significantly higher scores in the achievement test than those in the scientific heuristic class.

Table 2. Mean Score Comparison between the Control and Experimental Groups

Dependent Measure (Performance in College Algebra)	Control Group	Experimental Group	Computed Z-value[a]	p-value
	Mean Rank	Mean Rank		
Pre-test	6.17	8.50	-1.053	0.293
Post-test	3.67	10.38	2.986	0.003*

[a] Wilcoxon Rank Sum Test

A non-parametric statistical test particularly the Wilcoxon Rank-Sum test was used to test the score comparison between the control and experimental groups. The table shows the test of significance conducted and compared the mean ranks of the scores of the students in College Algebra.

The test of significance conducted and which compared the mean ranks of the scores of the students in College Algebra, as shown in Table 2, yielded p-values which was greater than $\alpha = .05$ (two tailed) in the pre-test. It clearly shows that there was no significant difference between mean rank scores of both groups before the experiment proper. The findings corroborates with the study of (Pescuela, 2006 & Alvaro, 1973), that data on achievement test shows that there was no significant difference between the mean scores of the classes before the experiment proper.

However, in the same table, the test of significance conducted and which compared the mean ranks of the scores of the students in College Algebra yielded p-values which was smaller than $\alpha = .05$ (two tailed) in the post-test. "This means that experimental group performed significantly better than the control group of students. This pattern is observable on the post-test indicator of the dependent variable. Hence the null hypothesis which states that there is no significant difference in the performance in college algebra between students in the experimental and control group is rejected". The test of significance conducted revealed that students exposed in the scientific heuristic method in teaching mathematics performed significantly better than those who were exposed in the traditional method of teaching mathematics.

The findings supported (Pescuela, 2006; Tiong, 2006; Foong, 2006; Tiong, Hedberg, & Lioe, 2005; Alvaro, 1973), results of the study showed that students who were exposed to heuristic approach performed significantly better in the post-experiment than the students who were exposed to the algebraic method of teaching.

Scientific heuristic method requires heavy involvements from students. It gives students chance to use their creativity to solve problems, from creating their own representations to discover or invent their own solutions, and creating their own heuristics. The results also showed that students have the capacity to develop invented strategies in solving problems, if they are not restricted in their methods of finding the solutions. Furthermore, results of the study revealed that some students, who were exposed to heuristic approach, developed a procedural understanding of solving the problems and extended the knowledge learned to unfamiliar or real-life situations while students who were exposed to algebraic teaching method developed conceptual knowledge that was of limited use to them.

Table 3. Proportion of Students Who Passed College Algebra in the Control and Experimental Groups

Dependent Measure (Performance in College Algebra)	Control Group		Experimental Group	Fishers Exact Test (2-tailed)
	Passed		Passed	
Post-test	40%		88.24%	0.008* **Very statistically significant**

The Fisher's Exact Probability test was used to test the proportion of passers in College Algebra between the control and experimental groups. A validation of the data analysis was conducted by classifying the post-test scores into pass or fail criterion. Operationally, a transmuted grade of 50% or better is considered a passing grade while less than 50% is considered a failure. The student respondents in each group were then classified based on this criterion.

The objective of the analysis is to compare the proportion of students in each group who obtained passing scores in the post-test. Because the data generated resulted into a 2x2 table and the data were nominal, the Fisher's Exact Probability test was used. The results of the data analysis are presented in Table 3". It can be gleaned from the above table, that the proportion of passers in College Algebra is higher for students in the experimental group than the control group. The Fisher's Exact Test yielded significantly different proportions post-test scores ($p < 0.05$, two-tailed). The two-tailed P value equals 0.008.The association between rows (groups) and columns (outcomes) is considered very statistically significant.

The validation of the data analysis conducted and which compared the number of passers in College Algebra between the two groups of students also yielded consistent results that a greater proportion of students in the experimental group than the control group.

4. Conclusions and Recommendations

The analysis of the data indicated that both the direct instruction (control group) and the scientific heuristic class (experimental group) scored significantly better on the post-test than they did on the pre-test relative to mathematical achievement. The experimental group however, out-performed the control group on the post-test. The results of this study indicate clear evidence that scientific heuristic method is superior to the direct algebraic instruction.

If the aim is to help students become effective problem solvers, then instruction on mathematical problem solving must also address. What one needs to become an effective problem solver is a repertoire of heuristics that are likely to be useful in a variety of problem situations. Until these processes receive explicit attention in the curriculum students may know fairly well what to do in routine and simple problem situations.

A future study could yield more meaningful results would be one that would measure more long-range effects that different methods of teaching would have on students' success in mathematics.

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