A Modular Approach Utilizing Decision Tree in Teaching Integration Techniques in Calculus

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Abstract – *This study was conducted to test the effectiveness of modular approach using decision tree in teaching integration techniques in Calculus. It sought answer to the question: Is there a significant difference between the mean scores of two groups of students in their quizzes on (1) integration by parts and (2) integration by trigonometric transformation? Twenty-eight second year B.S. Computer Science students at City College of Calamba who were enrolled in Mathematical Analysis II for the second semester of school year 2013-2014 were purposively chosen as respondents. The study made use of the non-equivalent control group posttest-only design of quasi-experimental research. The experimental group was taught using modular approach while the comparison group was exposed to traditional instruction. The research instruments used were two twenty-item multiple-choice-type quizzes. Statistical treatment used the mean, standard deviation, Shapiro-Wilk test for normality, two-tailed t-test for independent samples, and Mann-Whitney U-test. The findings led to the conclusion that both modular and traditional instructions were equally effective in facilitating the learning of integration by parts. The other result revealed that the use of modular approach utilizing decision tree in teaching integration by trigonometric transformation was more effective than the traditional method.*

Keywords – *Calculus, decision tree, integration techniques, Mathematics education, modular approach*

INTRODUCTION

Many students fail in Mathematics courses because they do not know how to arrive at the correct decision when doing a mathematical task. In this sense, educators need to assist their students how to think so that they would know how to decide appropriately. A good decision is a consequence of a process which involves higher-order thinking. Salandanan [1] pointed out that thought processes are more important than the knowledge itself. Students must be trained in the use of thinking skills because in actual life situations they are used to apply knowledge gained in solving problems, making decisions, and constructing new ideas. As a higher-order thinking skill, decision-making involves identifying a goal, collecting relevant information, recognizing alternatives, analyzing the alternatives, and selecting the best alternative.

Mathematics is decision-making. When given a mathematical task, one has to decide what operation to use, what concept or principle to employ, and what method or procedure to follow. The bigger question lies on how would a student grasp the procedure. There is always a high failure rate in Mathematics courses including Mathematical Analysis II. This may be attributed to the lack of ability of the students to understand mathematical concepts and execute mathematical procedures. The researcher's probable solution to this dilemma is to make use of decision tree in instruction. The procedure involved on the use of decision tree in learning Mathematics starts with identifying the goal. Then, relevant concepts will be gathered and analyzed until the best alternative is selected. The use of decision tree in teaching may be of great help to better understand and analyze a mathematical problem and the procedure used to solve it. It may improve the way teachers impart information and promote elaborative thinking of the students through incorporation of ideas. This visual tool may appeal to the eyes of the learner, thereby, may facilitate the learning of mathematical procedures. Hence, grounding a scientific study in Mathematics education through the use of decision tree makes perfect sense.

Modular instruction is one of those teaching approaches where the students have to learn

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everything in the module using his own effort at his own pace. This method differs from the traditional one wherein a teacher presents the lesson and the students just listen to learn the concepts presented. To surpass the difficulties faced by the students in the traditional classroom situation, modular approach may be a good alternative since it is student-centered, self-paced, and requires no note-taking.

In view of the preceding statements, this study attempted to use the modular teaching approach equipped with decision trees and assessed its effectiveness compared to the traditional lecture method. The following null hypothesis was tested at the 0.05 level of significance: There is no significant difference between the mean quiz scores of the experimental group and the comparison group in (1) integration by parts and in (2) integration by trigonometric transformation.

Some related references were gathered to construct, refine, and evaluate the present study. These also helped determine some problems and provide suggestions in the construction and utilization of modules and decision trees in teaching Mathematical Analysis II.

According to Victoriano [2], using a decision tree is most helpful in decision-making. A decision tree is a physical representation of a decision situation. The branches of the tree represent the alternatives. A decision tree helps the decision maker examine possible outcomes by providing an overview of the whole process. In addition, Bondigas [3] defined a decision tree as a graphical set of notes on processes or ideas, written down and connected with lines following the flow of thought. It helps the user reach a decision by laying out alternative courses of action. It makes ideas more understandable by putting them together in an ordered manner; thus, it can be an effective tool in the thinking process. A decision tree is as effective as the mind using it. The more thought that goes into a decision tree, the more useful it is. One potential problem in constructing a decision tree is that it is easy to put in unnecessary ideas which may sidetrack the user. McGew [4] added some weaknesses of a decision tree. It is difficult to interpret when it becomes large and complex. It is very susceptible to small changes. Any small alteration at the bottom of the decision tree will have effects at the upper portion. Lastly, as decision trees increase its complexity, the risk of losing track of the data becomes higher. Moreover, Michael Wills [5] pointed out that though a decision tree helps classify data, it takes time to construct and analyze it. The decision tree is only as accurate as the data integrated in it. Introducing inaccurate information at any of its node propagates this error throughout the rest of the tree. Consequently, this can lead to wrong decisions.

In the study conducted by Yin [6], the potential of tree diagram as an assessment tool to measure students' knowledge structures in statistics education was revealed. The results provide evidence of reliability and validity for the proposed function of using tree diagram as an assessment tool. As reliability evidence, the interrater reliability of tree diagram scoring is high (Pearson's $r = .96$). As validity evidence, experts performed better than beginners on the tree diagram assessment; there is a significant correlation between students' performance with the tree diagram and their performance on statistics achievement tests (Pearson's $r = .62$); tree diagrams are sensitive to the discrepancies in students' knowledge structures, and most students considered tree diagrams helpful to their organization of statistics knowledge.

Salandanan [1] described self-instructional materials as self-contained materials whose manner of presentation is such that the learning activities can be undertaken individually or in small groups. These are most effectively used in individualized instruction. One form of self-instructional material is the module. A module is a self-contained, independent unit of instruction prepared for the purpose of attaining defined instructional objectives. Characteristically, it is self-directing since instructions on how the various investigations will be followed are included. Modular approach is described as self-pacing since a student completes the prescribed learning tasks at his own pace. The module provides remedial instruction for slow learners and enrichment materials for fast learners. Consequently, he appreciates the lesson and gains a satisfying experience.

The study of Bedaure [7] investigated the effect of modular instruction on the performance in Biology of freshmen fishery students. It employed the pretest-posttest control group design of experimental research. In favor of the control group, there was a significant difference between the pretest results of the two groups. In favor of the experimental group, a significant difference was found between the posttest results. Therefore, modular instruction was better than the lecture-discussion in effecting students' performance in Biology.

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Valderama [8] evaluated the effectiveness of the online-modular instruction to mathematics achievement of high and low math ability group of students. The randomized pretest-posttest control group design using matched group subject was utilized. It was observed that the achievement level of the low math ability group exposed to online modular instruction declined. On the other hand, there was neither improvement nor decline in mathematics achievement of students in the high math ability group. As a result, the online-modular method in teaching mathematics is not advisable for use to low math ability groups. However, it could be adopted in teaching students with high math ability.

Another study of Valderama [9] determined the acceptability and effectiveness of the Instructional Module (IM) and Programmed Learning Sequence (PLS) in teaching Plane Geometry. The counter balanced with matched group quasi-experimental design was used. One group was taught using IM for the first set of topics then PLS for the second set. The other group was exposed to PLS first and then followed by the IM. The improvement in math achievement of the students exposed to IM and PLS was noted. Yet, the difference between the two teaching methods was not significant. Moreover, it is advisable that IM and PLS be adopted by the teachers handling geometry classes since their use were fully accepted by the students.

Mathematics is the backbone of all sciences. The importance of Mathematics in the study of any sciences, particularly Computer Science, is undeniable. For most Computer Science students at City College of Calamba, Mathematics acts more like a wall than a gateway. The researcher is usually mystified by their low performance in Mathematics, thus, thought of clarifying some dimensions of this problem and investigating a teaching method that may be effective as compared to the traditional way. The researcher, being in direct contact with his students, can see personally their predicament in learning Mathematics using the traditional lecture method. Some of these problems encountered by his students are as follows: (1) difficulty in coping with the lecture because it is group-paced; (2) difficulty in taking important notes because they have to listen and not all data are written on the board; and (3) difficulty in retaining information during and after the lecture. Nowadays, educators are experimenting on different methods of teaching which aim at improving students learning.

OBJECTIVES OF THE STUDY

The general objective of this study was to test the effectiveness of modular approach using decision tree in teaching integration techniques to BS Computer Science sophomores at City College of Calamba during the second semester of school year 2013-2014. Specifically, the study sought answer to the question: "Is there a significant difference between the mean quiz scores of the experimental group and the comparison group in (1) integration by parts and in (2) integration by trigonometric transformation?"

MATERIALS AND METHODS

Research Method

The study utilized the nonequivalent control group posttest-only design of quasi-experimental research. Its main concern is to compare the academic performances of the students exposed to modular instruction and those exposed to traditional teaching. This quasi-experimental design is appropriate for the study because it consisted of two intact groups, that is, its members are not randomly assigned. The experimental group was exposed to modular instruction while the comparison group was taught using the traditional method. At the end of the topics, a posttest was given to compare the performances of the two groups.

Participants and Sampling Technique

The population under study consisted of 43 regular (neither failed nor dropped a subject) second year from three sections of B.S. Computer Science students, namely II-CS1, II-CS2, and II-CS3, at City College of Calamba who were enrolled in Mathematical Analysis II for the second semester of school year 2013-2014. From II-CS1, II-CS2, and II-CS3, only 12, 18, and 13 students respectively were regular second year BS Computer Science students. All regular second year students from sections II-CS2 and II-CS3 were purposively chosen as respondents of the study. The representative sample was composed of 28 students: II-CS2 consisted of 18 students while II-CS3 had 10 students because 3 of them had dropped the course before the study started. Purposive sampling was employed since samples are selected based on the particular purpose of the study which is to compare the academic performances of

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regular second year B.S. Computer Science students taking up Mathematical Analysis II during the second semester of school year 2013-2014 at City College of Calamba. Using t-test for independent samples, it revealed that there was no significant difference between the class standings of the two groups in Mathematical Analysis I. This served as a basis for the equivalence of the two groups before subjecting them to the treatment.

Instrument

In order to measure the variables of this study, two researcher-made quizzes were utilized as instruments. Their contents were all about the techniques of integration: integration by parts for the first quiz and integration by trigonometric transformation for the second quiz. They were based on the course outline of Mathematical Analysis II of Computer Science and Information Technology Department of City College of Calamba. After determining the topics for inclusion in the quizzes, the tables of specifications were developed. It involved defining the objectives of a test and preparing and selecting the test items based on the defined objectives. The questionnaires were presented to the Mathematics experts, teachers who taught Mathematical Analysis II for at least three years, to ascertain the content validity. Moreover, for the purpose of validation, three students of City College of Calamba who had taken up Mathematical Analysis II read the same questionnaires to ensure that content including the instructions and questions were clear and comprehensible. After the intervention, the two twenty-item quizzes were administered to the two groups (one quiz per topic) to measure the difference in their levels of performance. Each question was scored one point per item.

Procedure

Before the data gathering process begins, the researcher secured permission to conduct the study from the Vice President for Academic Affairs of City College of Calamba who was also the Officer-in-Charge during that time. In planning for the development of each module and decision tree, the researcher identified some topics in Mathematical Analysis II that require decision-making. It included two techniques of integration, namely, integration by parts and integration by trigonometric transformation. He selected the appropriate format and content of the modules and decision trees by consulting to the thesis adviser and Mathematics instructors and examining relevant materials such as course syllabus, books, and online sources. And then, he constructed and submitted them, together with the quiz questionnaires, to the thesis adviser and four Mathematical Analysis II instructors for further revision and content validation. The thesis adviser made sure that the comments and suggestions by the other evaluators were accomplished by the researcher. The modules and questionnaires were also read by three students of City College of Calamba who had taken up Mathematical Analysis II to give feedback on the clarity of content including instructions and questions. The decision tree model constructed by the researcher is similar to but not exactly the same as the standard decision tree. Upon acceptance of the said experts, the modules equipped with decision trees and the quiz questionnaires were administered successively. The administration of the modules and questionnaires were accomplished through the guidance of the researcher’s fellow teachers, Mathematics experts, and thesis adviser. The researcher carried them out to two groups of respondents, namely, experimental group and comparison group that were subjected to two different methods of instruction. The experimental group was taught using modular approach while the comparison group received the traditional method of teaching. The researcher made sure that all topics for discussion to the two groups were synchronized during this stage of the experiment. Both groups were taught by the researcher with same time allotment and same course content. The quizzes were given one at a time to the two groups after the discussion of each topic. The scores of the respondents in the quizzes were tabulated. Analyses were made based on the results of the statistical treatment. The data were treated using mean, standard deviation, Shapiro-Wilk test, t-test for independent samples, and Mann-Whitney U-test.

Data Analysis

The data collected in this study were presented and analyzed by using of both descriptive and inferential statistics. The mean and standard deviation were used to describe the levels of performance of the two groups in each quiz. The Shapiro-Wilk test was utilized to determine whether the observed distribution is normally distributed or not. The two-tailed t-test for independent samples was used to compare the levels of performance of the groups in their quizzes on integration by parts since scores were

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normally distributed. The Mann-Whitney U-test was used to compare the levels of performance of the groups in the quiz on integration by trigonometric transformation as a nonparametric counterpart of t-test since the scores were found to be not normally distributed.

RESULTS AND DISCUSSION

There was no certainty about the significance of the difference between the mean quiz scores of the two groups. The t-test or Mann-Whitney U-test, depending on the normality of the observed distribution, was used to compare and analyze their mean scores in the two quizzes as shown in Table 1 and Table 2. The mean quiz scores were compared and analyzed to determine which method of instruction was more effective than the other. Using Shapiro-Wilk test of normality, the quiz scores on integration by parts were found to be normally distributed while the quiz scores on integration by trigonometric transformation was not normal.

Table 1. Groups' Levels of Performance in the Quiz on Integration by Parts

Group	Mean	Standard Deviation	*t*-Value
Experimental Group	11	3.1	0.48
Comparison Group	11.6	3.4	

Critical t-Value = 2.06

Table 1 shows that the mean quiz score of the experimental group was 11 with a standard deviation of 3.1 compared to a bit higher mean quiz score of the comparison group which was 11.6 with a standard deviation of 3.4. The observed distribution of scores was found to be normally distributed using Shapiro-Wilk test. Thus, the t-test for independent samples was utilized to determine if there is a significant difference between the mean quiz scores of the two groups. The computed t-value of 0.48 with 26 degrees of freedom was lower than the critical t-value of 2.06. This led to the decision of failing to reject the null hypothesis of no significant difference. It shows that, at 0.05 significance level, there was no significant difference between the levels of performance of the two groups in the quiz on integration by parts. The result of this analysis shows that both traditional instruction and modular instruction were equally effective in facilitating learning based on the quiz scores. It was revealed that even though there was a difference between the levels of performance of the students using the two methods of instruction, the effectiveness of modular approach over traditional method was not significant. The difference between the quiz mean scores may be due to sampling error.

Table 2. Groups' Levels of Performance in the Quiz on Integration by Trigonometric Transformation

Group	Mean	Standard Deviation	Mean Rank	*p* - Value
Experimental Group	14	2.6	16.97	0.031*
Comparison Group	11.3	3.3	10.05	

**Significant at 0.05*

Table 2 shows that the mean quiz score of the experimental group was 14 with a standard deviation of 2.6 compared to a lower mean quiz score of the comparison group which was 11.3 with a standard deviation of 3.3. The table also shows that the mean rank in the quiz performance of the experimental group was 16.97 compared to a lower mean rank of 10.05 of the comparison group. The use of mean rank, instead of mean, was due to non-normality of the observed distribution of scores as evaluated by Shapiro-Wilk test. Hence, Mann-Whitney U-test, instead of *t*-test, was utilized to compare the mean quiz scores of the groups. The *p*-value of 0.031 which was less than the significance level of 0.05 led to the decision of rejecting the null hypothesis. This shows that there was a significant difference between the mean ranks of the two groups in their quiz performance on integration by trigonometric transformation. In the discussion of integration by trigonometric transformation, a lot of examples were presented to illustrate the evaluation of the ten cases of integrals necessitating trigonometric transformations as compared to the examples given in integration by parts. Hence, the significant difference in the quiz performance may be attributed to the modules equipped with decision trees because of the exposure of the students to a greater number of examples utilizing decision trees. Furthermore, considering the standard deviations of the two groups from Table 2, observe that the experimental group had a smaller standard deviation than the comparison

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group. This implies that, on the average, the students from the group who received modular approach were more consistent in their mathematical ability with respect to the topic about integration by trigonometric transformation in comparison with the group who was taught using traditional method. Therefore, the result reveals that the use of modular teaching approach was more effective than the traditional method of instruction.

CONCLUSION AND RECOMMENDATION

In the light of the above findings, the following conclusions were drawn. There is no significant difference between the groups' levels of performance in the quiz on integration by parts. The difference in the mean quiz scores was 0.6. The mean quiz scores are considered the same and any difference is due to sampling error. These indicate that both modular instruction and traditional instruction were equally effective in facilitating learning based on the mean quiz scores. On the other hand, there is a significant difference in the groups' levels of performance in the quiz on integration by trigonometric transformation. The mean difference of 1.7 was high relative to the aforementioned mean difference. This is an indication that teaching Mathematical Analysis II using the instructor's self-made modules was more effective than the plain traditional method of teaching. The effectiveness of modular instruction may be attributed to the use of more examples which utilized decision trees in evaluating integrals using trigonometric transformation as compared to the number of examples illustrated in the topics about integration by parts. Also, it was observed that the modules equipped with decision trees took effect in its second administration to the experimental group which implies that sufficient time was necessary for the treatment to be effective.

On the basis of the findings and conclusions taken from the study, the following recommendations were proposed. In order to attain a more accurate result, it is suggested that the number of respondents be increased so that the result may be improved; time allotment be augmented so that the intervention takes sufficient time to effect; quiz items be increased by combining the first two topics for this will make the experimentation period longer; and number of examples be increased in integration by parts just like in integration by trigonometric transformation which yielded a significant result.

Though, in one instance, this study proved that modular instruction was more effective in teaching integration by trigonometric transformation to B.S. Computer Science students than the traditional method, mathematics instructors are advised to consider preparing modules adjusted to students' level of mathematical maturity and use them in teaching to improve their academic achievements.

This research utilized both modules and decision trees as instructional tools. The effectiveness may be attributed to either one of them or both. Researchers should carry out an experimental study assessing the effectiveness of instruction using decision trees.

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