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Comparative Effects of Printed and Computer-Assisted Forms of Modular Instruction

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Abstract

Using two experimental groups, a pre-test and two post-tests, this paper compared the effects of the printed and computer-assisted forms of a module on the acquisition and retention of knowledge, skills, understanding and problem-solving ability of students. The results reaffirmed the effectiveness of these two forms of instruction in uplifting mathematical proficiency ($p<0.01$). It was also found that the acquired skills of the printed module group (N=15) was significantly higher than that of the computer-assisted module group (N=15) ($p<0.05$). However, the printed module group was not able to retain their knowledge ($p<0.05$), skills ($p<0.01$), understanding ($p<0.05$), and problem solving ability ($p<0.01$) compared to the computer-assisted module group which had significant loss on problem-solving ability ($p<0.05$) only. It was concluded that the printed form of a module has better effects in terms of acquisition of learning but the computer-assisted form has better effects on the retention of learning.

Keywords: CAI; Knowledge; Module; Problem-solving; Retention; Skills; Understanding

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1. Introduction

Knowledge has always been considered as power. It serves as the foundation in the acquisition of skills, in establishing a better understanding of how the world works and in one's performance when engaged in real life situations. In mathematics, it is not enough that a student has knowledge, for example, of addition. Concept is not enough and he must also have the skill to execute addition however simple or complex the process may be. Moreover, his understanding on what, how, when and why addition should be performed is important. Furthermore, he must be able to use his knowledge, skills and understanding in dealing with problems in actual circumstances. And lastly, he must be able to retain what have been learned for future use.

The transition from the acquisition of knowledge to being able to apply it is an important aspect of learning. It is, however, a complex process that requires a constant evolution within a learning program as it is necessary for education to completely succeed. An important part that plays a vital role in that particular progression are the educational materials and interventions which are purposely designed to provide for the needs of every learner. These two should be closely monitored to ensure higher quality learning outcomes.

One trend that has been proven effective by various researches is the use of modules. The learning module comprises of different areas addressing the respective needs of the students in a specific subject matter or topic. One way that a module may be presented is through the traditional textual and pictorial approach where the student gains learning through perusing carefully written and structured lessons. Another possible way is to present modules through technology and take advantage of the salient features of computers to deliver learning instructions.

Whether traditionally written on paper only or computer-aided, these two types of delivering instructions have both advantages and disadvantages that may prove critical in the approach for meaningful learning. Information on the comparative effects of these two forms of instruction on the acquisition and retention of learning could provide stakeholders in mathematics education basis in their construction of intervention materials and policies to increase and strengthen proficiency among learners.

1.1 Statement of the problem

The significant role of printed modules and computer-assisted instructions in encouraging self-directed learning and in enhancing the proficiency of students in Mathematics is known to all stakeholders in the field of education. Various studies would support the effectiveness of each form of instruction. However, this study aims to directly compare the effects of these two forms of interventions on specific components making up the student's mathematical proficiency.

1.2 Objectives of the study

The general objective was to compare the effects of the printed and computer-assisted forms of modular instruction on the acquisition and retention of knowledge, skills, understanding and problem-solving ability.

The specific objectives were:

(i) To determine the proficiency of the students based on the results of the pre-test and post-tests.

(ii) To determine the statistical difference between the scores obtained on the three tests by the respondents in each group.

(iii) To determine the statistical difference between the scores of the two groups on the three tests.

1.3 Hypotheses

The hypotheses were:

H_{O1}: There is no significant difference between the results of the pre-test and the first post-test.

H_{O2}: There is no significant difference between the results of the first post-test and the second post-test.

$H_{O3:}$ There is no significant difference between the scores of the two groups during the pre-test, first post-test and second post-test.

1.4 Significance of the study

The comparison between the effects of the printed and computer-assisted forms of instruction was sought by the study. The results and findings obtained will be beneficial to all stakeholders in mathematics education as these may serve as basis in constructing intervention materials and in implementing policies to uplift the quality of learning outcomes.

1.5 The scope and limitation of the study

The study was concerned on the comparison of the proficiency and retention of the students after being exposed to the printed and computer-assisted forms of instruction. It was conducted in Emilio C. Bernabe National High School, Bagac, Bataan, Philippines, from August to October 2014 with a sample of 30 students divided equally into two groups.

The module used by the study was developed by the author, presented using two forms, and only covered the topics involving properties of right triangles, the Pythagorean Theorem, the six trigonometric functions and applications concerning the measurements of right triangles. Also, the software used to handle and deliver computer-assisted instructions was designed by the author. Each group was given their respective learning materials and was instructed to finish the requirements of the module in their own homes with no instructional assistance from the teacher. Thus, other interventions which may affect the learning process were not monitored and controlled by the study.

The research is comparative. However, it did not compare, but only briefly discussed, the natures of the printed and computer-assisted forms of instruction. Its concentration was on the effects of the two forms on learning and retention. Likewise, the research is experimental and its results were dependent on the abilities and cooperation of the chosen respondents. Efforts were made to ensure that the two sample groups were homogenous and that each respondent was motivated to complete the requirements of the experiment.

2. Materials and Methods

2.1 Research design

In order to meet the objectives of the study, an experimental research design, using one pre-test and two posttests, was employed. During the pre-experimental phase, a module was prepared and presented using two forms. After the conduct of the pre-test, two groups were formed: the printed module group and the computer-assisted module group, and each was given their respective intervention materials. To allow self-paced learning, 28 days were allotted for the experimental phase. The respondents were instructed to finish the requirements of the materials during their free time and at the comfort of their own homes with no assistance from the subject teacher. The post-experimental phase started with the conduct of the first post-test and 30 days after, the second posttest was given unannounced.

2.2 Sampling frame

Using a matched-pair sampling design [1], the 30 students chosen as respondents were distributed equally into two groups. The variables age, sex, general weighted average during the first grading period of the school year 2014-2015, and the results of the pre-test were used as basis in ensuring that the distributions of the respondents on the two groups were the same.

2.3 Instruments for data collection

The questionnaire was used as the instrument to collect data for the study. Both the pre-test and first post-test used the same set of questionnaire which was composed of 32 items designed to measure the (a) knowledge, or the ability of students to define and identify mathematical terms, (b) skills, or the ability of the students to process mathematical operations, (c) understanding, or the ability of the students to find the relationship between mathematical concepts, and (d) problem-solving ability of the respondents. Another questionnaire, containing similar items, was used for the second posttest.

2.4 *Method of data analysis*

The data collected were carefully tabulated and analyzed so as to draw conclusions on the phenomenon under study. Results of the pretest and first posttest were used to determine the improvement of the respondents in each group after being exposed to the interventions while the results of first post-test and the second post-test were compared to determine how much learning was retained. Lastly, the scores of the two groups were compared to measure the difference between the effects of each form of intervention. The paired-samples *t*-test and the independent samples *t*-test were used to answer the hypotheses of the study using the SPSS software.

3. Results

As shown in Table 1, the printed module (p.m) group obtained the mean score of 3.27 on the pre-test and 7.27 on the first post-test in terms of knowledge which was a significant increase with p=0.000 and a 95% confidence interval of difference of 3.34 to 4.47. On the same area, the computer-assisted module (c.m) group obtained the scores of 3.60 and 7.27 on the pre-test and first post-test respectively with an interval of difference of 2.65 to 4.69 significant at p=0.000. In terms of skills, the p.m group got the scores 2.40 and 7.13 on the pretest and first post-test respectively with interval of difference of 3.91 – 5.56 significant at p=0.000. The c.m group, on the other hand, obtained the scores 2.47 and 6.00 on the two tests respectively with interval of difference of 2.70 to 4.37 with p=0.000. As for understanding, the p.m group obtained the scores 1.80 and 5.00 on the pre-test and first post-test respectively with interval of difference of 2.60 to 3.80 and significance at p=0.000. On the same area, the c.m group obtained the scores 2.80 and 4.53 on the two tests with interval of difference of 0.74 to 2.73 and significance level of p=0.002. In terms of problem-solving ability, the p.m group obtained the scores of 1.27 and 4.47 on the two tests with interval of difference of 2.53 to 3.87 which was significant at p=0.000. The c.m group, on the other hand, got the scores of 1.53 and 4.47 on the pre-test and first post-test respectively with a 95% confidence interval of 2.11 to 3.78 which was significant at p=0.000.

Table 1: Analysis of scores on the pre-test and first post-test

Area	Pre-test	First post-test	95% confidence interval of difference	t-value	p-value
Knowledge	3.27 ± 1.22	7.27 ± 1.16	3.35 – 4.47	18.330	0.000
	3.60 ± 1.64	7.27 ± 0.80	2.65 – 4.69	7.723	0.000
Skills	2.40 ± 1.35	7.13 ± 0.92	3.91 – 5.56	12.333	0.000
	2.47 ± 1.06	6.00 ± 1.56	2.70 – 4.37	9.089	0.000
Understanding	1.80 ± 0.86	5.00 ± 1.20	2.60 – 3.80	11.451	0.000
	2.80 ± 1.82	4.53 ± 1.51	0.74 – 2.73	3.747	0.002
Problem-Solving	1.27 ± 0.80	4.47 ± 1.19	2.53 – 3.87	10.267	0.000
Ability	1.53 ± 0.99	4.47 ± 1.25	2.11 – 3.78	7.643	0.000

Note: Top and bottom values per area are for printed and computer-assisted module groups respectively.

Based on Table 2, the mean scores of the p.m group on the knowledge dropped from 7.27 on the first posttest to 6.67 on the second post-test with a 95% confidence interval of difference of -1.15 to -0.54 significant at p=0.033. On the other hand, the c.m group obtained scores of 7.27 on the first post-test and 7.07 on the second post-test but the difference was not significant with p=0.582. In terms of skills, the p.m group got the scores of 7.13 and 6.00 on the two post-tests with interval of difference of -1.88 to -0.38 which was significant with p=0.006. The c.m group, however, obtained the scores 5.00 and 4.33 on the first and second post-tests respectively but the difference was not significant with p=0.164. As for understanding, the p.m group obtained the scores 5.00 and 4.33 on the two post-tests with interval of difference of -1.28 to -0.05 which was significant with p=0.036. On the other hand, the c.m group obtained the scores 4.53 and 3.87 on the two post-tests but the difference was not significant with p=0.290. In terms of problem-solving ability, the p.m group obtained the scores 4.47 and 3.00 on the two tests with interval of difference of -2.25 to -0.069 which was significant with p=0.001. The c.m group, on the other hand, obtained the scores 4.47 to 3.07 on the first and second post-tests respectively with a 95% confidence interval of difference of -2.46 to -0.34 which was significant with p=0.014.

Table 2: Analysis of scores on the first post-test and second post-test

Area	First post-test	Second post-test	95% confidence interval of difference	t-value	p-value
Knowledge	7.27 ± 1.16	6.67 ± 1.54	-1.15 – -0.54	-2.358	0.033
	7.27 ± 0.80	7.07 ± 1.10	-0.96 – 0.56	-0.564	0.582
Skills	7.13 ± 0.92	6.00 ± 1.20	-1.88 – -0.38	-3.238	0.006
	6.00 ± 1.56	5.60 ± 1.06	-0.99 – 0.19	-1.468	0.164
Understanding	5.00 ± 1.20	4.33 ± 1.72	-1.28 – -0.05	-2.320	0.036
	4.53 ± 1.51	3.87 ± 1.85	-1.97 – 0.64	-1.099	0.290
Problem-Solving	4.47 ± 1.19	3.00 ± 1.25	-2.25 – -0.69	-4.036	0.001
Ability	4.47 ± 1.25	3.07 ± 1.39	-2.46 – -0.34	-2.824	0.014

Note: Top and bottom values per area are for printed and computer-assisted module groups respectively.

Table 3: Comparison of scores of the two groups on the three tests

Area	Mean Difference	95% confidence interval of difference	t-value	p-value
Knowledge	-0.33	-1.42 – 0.75	-0.631	0.533
	0.00	-0.75 – 0.75	0.000	1.000
	-0.40	-1.40 – 0.60	-0.818	0.421
Skills	-0.07	-0.98 – 0.84	-0.150	0.882
	1.13	0.17 – 2.09	2.429	0.024

	0.40	-0.44 – 1.24	0.972	0.340
Understanding	-1.00	-2.09 – 0.09	-1.923	0.069
	0.47	-0.55 – 1.48	0.940	0.355
	0.47	-0.87 – 1.80	0.717	0.480
Problem-Solving	-0.27	-0.94 – 0.41	-0.812	0.424
Ability	0.00	-0.91 – 0.91	0.000	1.000
	-0.07	-1.06 – 0.92	-0.138	0.891

Note: Top, middle and bottom values per area are for the pre-test, first post-test and second post-test respectively.

Through Table 3, it was found that the difference between the scores of the two groups on the pre-test in terms of knowledge, skills, understanding and problem-solving ability was not significant with p-values of 0.533, 0.882, 0.069 and 0.424 respectively. During the first post-test, however, while significant difference between the scores of the two groups were not found on the areas of knowledge, skills and understanding, a significant difference was established between the scores in terms of skills with a 95% confidence interval of difference of 0.17 to 2.09 with p=0.024 favoring the printed module group. As for the results of the second post-test, no significant difference was found between the scores of the two groups in terms of the four areas.

4. Discussion

The study confirmed the effects of the printed form [2] and the computer-assisted form [3] of a module in increasing the proficiency of students in mathematics. Even at a self-directed learning environment and with no assistance from the teacher, the students gained learning from the interventions proving what they can do when given the chance to learn by themselves [4]. However, assistance of the teacher on the areas involving critical thinking are still necessary to further increase understanding by helping the students on the conceptual building blocks necessary to make sense of the abstract language of mathematics [5] and to further improve the problem-solving ability of the students.

It was established that the distribution of the respondents across the two groups based on the results of the pre-test was not statistically different. However, after being exposed to the interventions, respondents on the printed module group obtained significantly higher proficiency in terms of skills compared to those in the computer-assisted module group. Printed modules, like books, provide hands-on experience [6] and they are tangible [7] which enable students to put marks on them, easily flip between pages to gain more grasp of the mathematical processes involved and review even before an examination.

On the other hand, 30 days after finishing the requirements of the interventions, respondents from both groups obtained similar scores on the second post-test. Comparison between the scores on the two post-tests would suggest that the respondents, in general, obtained losses on all four areas. Forgetfulness is a fundamental truth in memory theory [8], thus, students will eventually forget what were previously learned. This phenomenon is a great challenge to instructional designers [9]. Practice drills should be regularly conducted to reinforce learning.

The respondents on the printed module group, however, gained significant mean losses on all four areas compared to the respondents on the computer-assisted module group who gained significant mean loss on their problem-solving ability only. This would suggest that the students who were exposed to the printed form of the module were not able to retain what had they previously learned compared to the students who were exposed to the computer-assisted form. Computer-assisted instruction's effect on stronger retention [10; 11] may be attributed to the fact that it is more interactive and more rewarding [6] and, compared to the printed form, it provides immediate feedback [12] which may strengthen the associations built during the learning process.

5. Conclusion

Modules play an important role in encouraging the students to learn by themselves. However, no single form or presentation of an instruction could well provide for all the needs of the learners. Both the printed and computer-assisted forms of a module are effective in increasing the mathematical proficiency of the students even in a self-directed learning environment. The printed form of a module, though, is more effective in terms of acquisition of learning. On the other hand, the computer-based module is more effective in in terms of retention of learning.

The study, therefore, recommends that caution should be exercised in using these two forms. Modules should be used to encourage students to learn by themselves and mixing these two forms of instruction could provide for a richer learning experience and more meaningful outcomes. Further researches are also needed to enable stakeholders to fully take advantage of the salient characteristics of the printed and computer-assisted forms of instruction.

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