THE EFFECTIVENESS OF AN INTERACTIVE COURSEWARE USING THREE DIFFERENT STRATEGIES

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Abstract

This paper examines the cognitive effects, in terms of the gain scores and time-on-task of a computer courseware using collaborative and mastery learning strategies. A total of 262 Form Four students from four Malaysian schools interacted with two Matrices courseware: one with mastery learning elements (used in CML and CCML strategies) and another without mastery learning elements (used in CCL strategy). This study showed that, CCML and CML were the effective learning tools. If the time allocated for the learning process is longer, CCML would be the most ideal strategy otherwise CML is generally preferred in the learning process.

Introduction

With the advent of information and communication technology (ICT), educators take opportunities to harness the power of computer technology in helping students to learn mathematics. For example, multimedia presentation allows the learners not only to read and to observe but also to listen to the discussion in the learning process. Hofstetter (1995) reasons out the usability of multimedia in his research report that student retain only 20% of what they see, 30% of what they hear but 50% of what they see and hear and as much as 80% of what they see, hear and do simultaneously.

Using computers to help students to learn mathematics through the use of courseware is not uncommon to the Malaysian students. There are a number of researches done in Malaysia pertaining to the use of multimedia in learning mathematics. Nor Azan Mat Zin (2009) found in her study that the courseware which matches students' learning styles to instructions has improve students' learning gains compared to students under mismatched of learning styles in using the courseware. Zurina Muda and Ros Emiliana Kartina Mohamed (2005) developed a courseware to introduce basic mathematics knowledge for preschool students. Mastery learning has been added lately in the use of multimedia for the learning of mathematics to make the learning more interesting (Norjihan Abdul Ghani, et al., 2006). It is also learned that mastery learning can be conducted more convincingly and flexibly through multimedia. However, the success of a courseware using mastery learning depends on the design and development of the instruction and also the approach used in conducting the courseware. Therefore there is a need for more studies to examine various designs and approaches that can complement a courseware performance. This paper focuses on the development and the investigation of the use of a courseware employing three different strategies.

Literature Review

In mastery learning all learners attain the required learning objectives. The basic mechanics of mastery learning lies in the five basic components of mastery learning: the learning objectives, instruction, formative assessment, feedback (includes correctives and enrichments) and the summative evaluation of competent learners (Guskey, 1989). Among these, *instruction* and *feedback* are the most important. These two components are crucial because students need to attain the required concepts before they can proceed to the higher level of learning units (Bloom, 1968, 1974). In a mixed ability classroom, teachers often have difficulties in monitoring the performance of students from different ability levels and the grading process takes up a lot of time. The complexity of this task was acknowledged by Boggs, Shore and Shore (2004) when they identified four obstacles which must be overcome when applying mastery learning: 1) creating multiple versions of each test; 2) grading multiple versions of tests for students at varying stages of the course; 3) scheduling time for students to take several versions of tests, if needed, to attain a certain level of mastery; and 4) teaching students who are at different learning objectives.

Modern computer technology has enhanced the administration of mastery learning. Mastery learning incorporated with cooperative learning strategy proves to be effective in delivery a lesson. Bork (1999) and Cohen (1991) noted that a well-designed mastery learning instruction within a cooperative learning situation provides a better guidance for students in their learning. The cooperative features cater to meet diverse needs of students through team activities. For instance, students are fully engaged and they help each other in clarifying misunderstandings and correcting learning errors in order to achieve a criterion-referenced standard.

Methodology

The sample for this study consisted of 262 students aged 16 years old randomly chosen from four suburban secondary schools (known as schools *A*, *B*, *C* and *D*) in Seberang Perai. For each school, three intact classes were chosen randomly. School *A* was randomly assigned to the Computer-assisted Cooperative Learning (CCL) treatment, schools *B* and *D* were assigned to the Computer-assisted Mastery Learning (CML) treatment, and school *C* was assigned to the Computer-assisted Cooperative Mastery Learning (CCML) treatment. The number of students in CCL, CML and CCML were 77, 81 and 104 respectively. All students had not been exposed to the topic of Matrices.

The researcher has developed a courseware entitled "Matrices" by using Macromedia Authorware 5.0 as the authoring tool. A series of templates were created through rapid prototyping. There were two sets of courseware used in this study. The first courseware was designed with mastery learning elements, which was used in the CML and CCML strategies. The second courseware was designed without mastery learning elements, which was used in the CCL strategy. Before conducting the experiments, the courseware was field tested.

Gain scores and time-on-task were taken to investigate the effectiveness of the mentioned strategies. Before the experiment was conducted, all the samples went through the entry test on basic knowledge on Matrices. Students with score 80% and above in the entry test were allowed to proceed in the experiment without undergoing through the activities to strengthen their prior knowledge. Students who achieved less than 80% were required to go through the interactive activities to strengthen their prior knowledge.

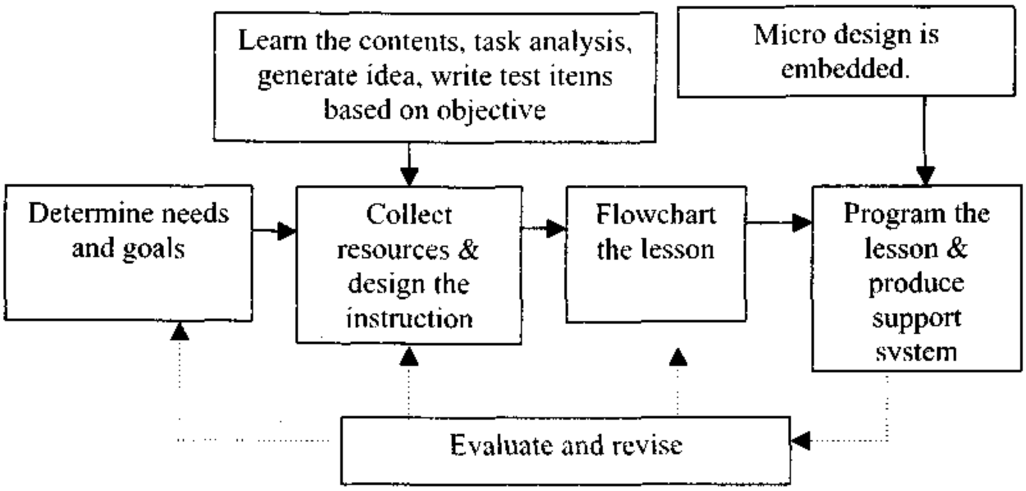
Data was collected over four months. On the first day of the data collection, students were given a briefing on the learning strategies. They were given a pre-test on *Matrices* and it was followed by a lesson on *Matrices* and *Equal Matrices* on the second day. After the lesson, the students were given the first formative test through the computer. The subtopics covered in the whole process were (1) Matrices and Equal Matrices; (2) Addition and Subtraction on Matrices; (3) Multiplication of a matrix by a number; Multiplication of two matrices; and (4) Identity Matrix, Inverse Matrix and solution of simultaneous linear equations by using Matrices.

The whole lesson on *Matrices* took four to six hours to finish. Students took a test after each subtopic. The differences of the three treatment groups in terms of presentation of the lessons, team function and individual improvement were noted by the researcher. Students in the mastery learning condition (CML) completed all formative tests or quizzes independently. Students who failed to meet the required performance level received supplementary instruction and corrective activities immediately after each question until the requirement was met. Students in the cooperative learning condition (CCL) and the cooperative mastery learning condition (CCML) groups underwent all designated cooperative learning activities. They completed all tests independently. CCL received no corrective activities but CCML students who failed to meet the required performance level received supplementary instruction and correction activities immediately after each question until the requirement was met. For CML and CCML groups, at the end of a test, extra corrective activities were given to those who could not achieve the satisfactory level of 80% as evaluated by the computer. In CCML group, each student must wait until all members in the group have achieved the level of 80%. Those who successfully achieved 80% and above were encouraged to help those who have yet to achieve 80% of the score.

Courseware

The steps to design the courseware were adopted from the Alessi and Trollip's instructional design model (1985). Figure 1 shows the process of the macro design according to the Alessi and Trollip's model. The procedures of 'determine needs and goals', 'collecting resource and design the instruction', 'flowchart the lesson' and 'program the lesson and produce support system' are evaluated and revised throughout the whole process.

Figure 1: The Steps in the Macro Design



Gagné's nine events of instruction (Gagné, 1985; Gagné, 2000) in Table 1 were referred to organize the learning conditions in the micro design courseware. Keller's ARCS model (Keller & Suzuki, 1983) was adopted to include motivational elements of instruction to enhance learning. The model incorporates motivational strategies in the area of learner's attention, relevance, confidence and satisfaction. More importantly, the entire system of instruction was tailored using the mastery learning approach.

Table 1: Incorporating the Conditions of Learning (Gagné, 1985) and Motivational Strategies (Keller and Suzuki, 1983) into Instructional Situations

Conditions of Learning	**Instructional Situation**	**Incorporating motivational elements using ARCS model**
1. Gaining attention	Graphic and video is emphasized to present an introductory scene.	Attention: Strategies for arousing and sustaining curiosity and interest.
2. Informing the learner of the objective		Relevance: Strategies that link to learners' needs, interests, and motives.
3. *Stimulating recall of prior learning (enhancement of cognitive prerequisites)	Hyperlink	
4. *Presenting the stimulus material (enhanced cues)	Cues	
5. *Providing learning guidance (ideas of cueing, organizing and student participation)		
6. *Eliciting the performance	Quizzes	Confidence: Strategies that help students develop a positive expectation for successful achievement. Satisfaction: Strategies that provide extrinsic and intrinsic reinforcement for effort.
7. *Providing feedback (corrective activities)	Feedback for every question. Corrective activities are provided for those who have not mastered the knowledge. Enrichment activities are provided for those have mastered the knowledge.	
8. Assessing performance	Test on Paper	
9. Enhancing retention and transfer	Activities	

* This represents the most important components in mastery learning

Results

The following results are reported based on the two hypotheses in this study.

Hypothesis 1: There are no significant differences in the dependent variables among the students in the CCL, CML and CCML strategies.

H1.1 There is no significant difference in the gain scores among students in the CCL, CML and CCML strategies.

H1.2 There is no significant difference in the time-on-task among students in the CCL, CML and CCML strategies.

Descriptive Statistics on Gain Score for the Three Learning Strategies

The descriptive statistics on gain scores for CCL ($Gain_{CCL}$), CML ($Gain_{CML}$) and CCML ($Gain_{CCML}$) are shown in Table 2. It can be seen that the mean of CCML was the highest, which was 49.40. CML with the mean of 42.79 was the second highest; while the mean of CCL was the lowest, which was 31.47. Thus, $Gain_{CCML} > Gain_{CML} > Gain_{CCL}$.

Table 2: Descriptive Statistics on Gain Score for CCL, CML and CCML

	CCL	CML	CCML	Total
Mean	31.47	42.79	49.40	42.09
N	77	81	104	262
Std Dev	19.206	19.678	17.849	20.164
Var	368.884	387.218	318.573	406.578
Skewness	0.832	0.581	-0.030	0.285
Median	28	37	50	40

These results showed that $Gain_{CCML}$ was the highest and had the least variability, with the smallest value of variance as compared to CCL and CML. These indicated that mastery learning in CCML could raise the level of students' achievement, with less variability among them. Thus, CCML gave a better distribution in gain scores as compared to CML and CCL.

Descriptive Statistics on Time-on-task for the Three Learning Strategies

Reported in Table 3 are the descriptive statistics on time-on-task for CCL ($Time_{CCL}$), CML ($Time_{CML}$) and CCML ($Time_{CCML}$). It can be seen that the mean of CCML was the highest, which was 4.71 hours. CCL with a mean of 3.90 hours was the second highest, whereas the mean of 3.70 hours was the lowest. Thus, $Time_{CML} < Time_{CCL} < Time_{CCML}$.

Table 3: Descriptive Statistics on Time-on-task (in hours) for CCL, CML and CCML

	CCL	CML	CCML	Total
Mean	3.90	3.70	4.71	4.16
N	77	81	104	262
Std Dev	0.771	1.030	0.784	0.973
Var	0.594	1.061	0.615	0.947
Skewness	0.182	1.261	0.427	0.285
Median	4	3	5	4

MANOVA in Analyzing of the Effect of Learning Strategies on the Dependent Variables (Gain Score and Time-on-Task)

The results of the MANOVA test (Table 4) showed that the Wilk's lambda of 0.549 was significant, $F(4, 516) = 45.032$, $p < 0.05$. Thus, *Hypothesis 1*, which states that the population means on dependent variables (i.e., gain scores and time-on-task) were the same for the three groups, was rejected. The multivariate Eta Squared indicated that 25.9% of multivariate variance of the dependent variables was associated with the group factor.

Table 4: Multivariate Tests of the Effect of Learning Strategies on the Dependent Variables

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
strategies	Wilks' Lambda	.549	45.032	4.000	516.000	.000	.259

Using multiple univariate ANOVAs, a follow-up approach was conducted. Two ANOVAs were conducted, one for each dependent variable (i.e., gain scores and time-on-task). The results of the univariate ANOVAs were shown in Table 5. The univariate ANOVA for gain scores was significant, $F(2, 259) = 20.155$, $p < 0.025$, likewise the univariate ANOVA for time-on-task was significant, $F(2, 259) = 36.066$, $p < 0.025$. Both results showed that there were significant differences of gain scores and time-on-task among the groups. Therefore, Hypothesis 1.1 and Hypothesis 1.2 were rejected.

Table 5: Univariate Tests of the Effect of Learning Strategies on the Dependent Variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Gain Scores	14291.342	2	7145.671	20.155	.000	.135
	Time-on-task	53.863	2	26.932	36.066	.000	.218
Intercept	Gain Scores	437568.203	1	437568.203	1234.189	.000	.827
	Time-on-task	4336.984	1	4336.984	5807.944	.000	.957
Strategies	Gain Scores	14291.342	2	7145.671	20.155	.000	.135
	Time-on-task	53.863	2	26.932	36.066	.000	.218
Error	Gain Scores	91825.639	259	354.539			
	Time-on-task	193.404	259	.747			
Total	Gain Scores	570219.000	262				
	Time-on-task	4782.000	262				
Corrected Total	Gain Scores	106116.981	261				
	Time-on-task	247.267	261				

Since ANOVAs for both dependent variables yielded significance result and the factor contained more than two levels, additional follow-up tests were performed. To be consistent with the above analyses, each comparison was tested at the alpha level for the ANOVA divided by the number of comparisons. Thus, the significant level used was 0.008. The Levene-test Equality of Error Variances (Table 6) showed that there were equal variances among the groups in gain scores, but unequal variances among the groups in time-on-task. The pairwise comparisons using Bonferroni approaches were used in the follow-up analyses across the pairwise comparisons in gain scores. The result indicated that there were significant differences in gain scores for the two pairs- CCML with CCL and CML with CCL. Dunnett's C approaches were used in the follow-up analyses across the pairwise comparisons in time-on-task since the homogeneity test in Levene-test gave the significant level of 0.007 ($p < 0.05$), which showed that there were unequal variances among the groups. Table results indicated that there were also significant differences in time-on-task for the two pairs- CCML with CCL and CCML with CML.

Table 6: Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Gain Scores	.677	2	259	.509
Time-on-task	5.043	2	259	.007

The Effect Sizes of Learning Strategies on the Gain Score

Effect sizes (Table 7) of CML and CCML towards CCL were studied because there were significant differences between CML and CCL as well as between CCML and CCL. The results showed that the effect size of CML towards CCL was 0.5603, which was moderate. This means that an individual learner in CML have a 0.5603 standard deviation increase. The effect size of CCML towards CCL was 0.8778. Therefore, effect size of CCML towards CCL was stronger if compared to the effect size of CML towards CCL.

Table 7: Effect Size

	Effect size
CML towards CCL	0.5603
CCML towards CCL	0.8778

Discussion

There were significant differences in independent variables of gain scores and time-on-task across the learning strategies. Generally, there were significant differences in gain scores across the learning strategies. The effect size in gain scores suggested that the CCML strategy had more positive effect than the CML strategy. These results supported the findings from past researches that cooperative mastery learning produces better results (Akinsola, 1996; Krank & Moon, 2001; Laney et al., 1996). Furthermore, these results were consistent with Mevarech's (1985) and Okebukola's (1985) findings that cooperative learning has positive effects in the application of Student Team Achievement Division (STAD) approach and even better effects if STAD was combined with mastery learning.

Although the CCML strategy had better results in the gain scores, it showed no significant difference in the gain scores between the CCML and CML strategies. In this case, the contribution of the CML and CCML strategies were equally important in terms of the gain scores in which both learning strategies had mastery learning. In other words, mastery learning plays an important role in the gain scores. This explained the essential role that the component of mastery learning plays in terms of organizing a systematic and more structured instruction in order to guide students. However, incorporating cooperative learning could strengthen the role of mastery learning. Additionally, this study found better effect size when the CCML strategy was used indicating that students in cooperative mastery learning groups were well guided in the designed mastery learning environment.. This is consistent with Okebukola's (1985) findings that cooperative learning could strengthen students' performance. Also, this finding supported Mevarech's

(1991) view that mastery learning has been successful in producing gains in achievement. Mevarech (1985) such programme the cooperative mastery learning. In terms of time-on-task, the CML strategy played an important role to increase gain scores and decrease time-on-task. The major finding is the students in the CML and CCL strategies spent shorter time-on-task compared to the CCML strategy. The results were consistent with past researches (Mortimore and Sammons, 1987).

Conclusion

Although mastery learning (systematic work) was the most important instructional method to make students succeed, it is better when supported by cooperative learning. The findings of this study showed that mastery learning built-in with cooperative learning features improves the gain score of the students. The CCML strategy was found to be the most effective learning strategy in this study because it caters for students who are socially reserve and also those who seek peer guidance during the learning process.

Zimmerman (1998) noted that the more time-on-task is made available to the student, the more activities and learning processes are involved and acknowledged that time is a critical factor but it has little direct impact on students' performance. Essentially, students must be provided with activities and instructions that cater to their needs and abilities, engaging them so they will continue to build on what they have learnt. This study has shown that the CML and CCML strategies can provide those catalytic moments when students are absorbed in instructional activities that are adequately challenging, yet allow them to experience success. From the practical aspect, this study showed that both learning strategies, CCML and CML were effective learning tools to students. The conclusion is that under the mastery learning instruction, it is the cooperative features that cause CCML to give a stronger effect size than CML in the gain score. On the aspect of the time-on-task, CML took significantly less time and therefore is generally preferred in the learning process based on the result of better gain scores as compared to CCL. However, if the time allocated for the learning process is longer and unrestricted, then CCML would be the most ideal strategy.

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