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Effect of an Interactive Courseware in the Learning of Matrices

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ABSTRACT

The main aim of this study is to integrate cooperative learning strategies, mastery learning and interactive multimedia to improve students' performance in Mathematics, specifically in the topic of matrices. It involved a quasi-experimental design with gain scores and time-on-task as dependent variables. The independent variables were three instructional strategies (CCL, CML and CCML) with academic abilities as the moderator variable. The sample for the study was 262 Form Four Malaysian students. A courseware entitled "Matrices" was developed using Macromedia Authorware as the authoring tool. In this study, the collected data was used to investigate the effects of the three learning strategies on the gain scores and time-on-task. Based on the gain scores and time-on-task, the effectiveness of the three learning strategies was discussed. This study showed that the CCML and CML strategies were superior compared to the CCL strategy; CCML strategy produced the highest gain score. For students with low academic ability, the CML strategy was found to be the most effective strategy. The findings of this study also suggested that high academic ability students would obtain high gain scores regardless of the instructional strategies. In terms of time-on-task, students in CCL and CML strategies demonstrated significant lower time-on-task than CCML strategy.

Keywords

Computer-assisted cooperative learning (CCL), Computer-assisted mastery learning (CML) and Computer-assisted cooperative mastery learning (CCML)

Background of the study

One of the major problems among mainstream secondary school students is the performance difference between the low achievers and the high achievers. To overcome this problem, various interventions had been offered including curriculum-based assessment (Fuchs, Fuchs and Tindal, 1986), direct instruction curriculum design (Engelman and Camine, 1982), mastery learning (Bloom, 1984), tutoring (Sleeman and Brown, 1982), learning strategies (Mason, Burton and Stacey, 1982), and so forth. Unfortunately, most of these interventions required additional resources such as teachers' efforts and time needed to use them. However, the advent of Information and Communication Technology (ICT) in the last few years has eased the burden on the resources needed for the teaching and learning process. The use of computer as an ubiquitous teaching tool has become prevalent in Malaysian schools. As a result, the use of computer in conjunction with effective teaching strategies has tremendous potential in the teaching and learning process.

With the use of computer, mastery learning has a high potential to become an effective and extensive teaching and learning tool (Guskey, 1997; Guskey and Gates, 1986; Kulik, Kulik, and Bangert-Downs, 1990). The mastery learning method divides subject matter into units and each unit has predetermined objectives. Students should achieve mastery on unit tests, typically 80%, before moving on to the following units. Students who do not achieve mastery receive remediation and students who achieve mastery have the opportunity to participate in enrichment activities. Mastery learning fits well with other strategies and complements cooperative learning (Guskey, 1997). Researchers, such as Dansereau (1988), Gunderson and Johnson (1980), Hooper, Temiyakarn, and Williams (1993), had strongly recommended that cooperative learning should be used in the teaching and learning process. As suggested by Guskey (1997), it needed a comprehensive framework to incorporate other instructional strategies into mastery learning. Guskey (1997) had suggested cooperative learning as one of the instructional strategy. Cooperative learning as part of collaborative learning has gained educators' attention to include it into process of learning (Wells and Brook, 2004). A meta-analysis based on 39 rigorous studies on a common basis in science, mathematics, engineering and technology showed that generally, cooperative learning significantly increased academic performance, decreased dropout rates and increased student self-confidence (Springer, Stanne & Donovan, 1999).

Cooperative learning was preferable to be incorporated into mastery learning since the goal of using cooperative learning was to accomplish a specific learning task through people working together in groups (Panitz, 1997). The learners were more concerned with mastery of a pre-determined body of knowledge. In other words, mastery learning complemented and fitted well with cooperative learning (Guskey, 1997).

Over the years, studies by Guskey and other researchers (Atkinsola, 1996; Mevarech, 1985) had found that cooperative learning could be incorporated into mastery learning to present a conducive learning environment for students. Students who focused on specific instructional goals were actively engaged in cooperative learning activities, thus, effective study time was increased. Students were properly guided with mastery learning materials in a cooperative learning environment in order to strengthen their skills of self-awareness and personal controls in learning. Hence, cooperative learning was considered an efficient way of increasing effective study in mastery learning. Results from the above studies had shown that the combination of mastery learning and cooperative learning were found to be superior to the traditional lecture teaching format. Specifically, these studies indicated that mastery learning and cooperative learning had an impact on affective and academic outcomes of students.

The combination of systematic design and integration of cooperative learning strategies, mastery learning and interactive multimedia might have a great impact on the teaching and learning of subjects, such as Mathematics, where hierarchical knowledge is the requirement of the field. Mathematics learning skills could easily be learned in a cooperative setting. Cooperative learning provided opportunities to students with low academic abilities to model their study skills and work habits as compared with high academic abilities. With the help given by students with high academic abilities in explaining in detail the steps in the worked-out examples, weaker students were then convinced to use these skills in order to obtain a mathematical solution. Besides, students with high abilities often developed greater mastery during discussions by obtaining a deeper understanding of the task (Becker, Silver, Kantowski, Travers, and Wilson, 1990; Stigler, Lee, Lucker, and Stevenson, 1982). With mastery learning, cooperation needs were structured and guided through systematic instruction and feedback.

In learning mathematics, a diagnostic test (Teoh, 2003) had shown that students with difficulties in matrices were also weak in the basic skills of mathematics, such as solving equations. Specifically, students who experienced difficulties in matrices would find doing multiplication of two matrices confusing. It showed that the basic skills in mathematics had become a necessity in solving problems and understanding other concepts in mathematics (Wu, 1999). Furthermore, to avoid omission of important processing skills, students had to be trained to master the basic skills in the early stages of the learning experience with enough time and quality instruction (Bloom, 1968). If the students were not provided with enough time, they might find difficulty to proceed to a higher stage of learning (Harrell, Walker, Hildreth and Tayler-Wood, 2004). Without the awareness, weak students were found with no improvement in their skills in mathematics. In contrast, if teachers tended to focus only on weak students, then students with good performance would not be able to get the teachers' attention in the learning process. Subsequently, mastery learning played an important role in providing an environment for students to be involved in their study, whereby students with high and low abilities were able to learn at their own pace, with the help of feedback corrective and enrichment activities. However, each component of mastery learning involved a great amount of work which made it inapplicable to the manageability and constraints relating to time (Anderson and Jones, 1981; Levine, 1985). As an example, excessive amount of testing, corrective and enrichment activities were needed during 'feedback', an important component in mastery learning. The time allocation for subjects in the normal school curriculum was evidently not sufficient for mastery learning to be applied. Currently, the use of the e-learning platform to teach developmental mathematics in a mastery learning format had been promoted to overcome this obstacle (Boggs, Shore and Shore, 2004).

With the advent of ICT as a teaching tool and the availability of computer hardware in the schools, the problem in applying mastery learning could be improved by using interactive courseware. Feedback activities could also be easily conducted by using computers. In addition, for recording purposes of students' performance, the technology could also reduce time and effort required to implement comprehensive interventions needed in mastery learning materials.

Objectives of the study

This study is mainly aimed to integrate cooperative learning strategies, mastery learning and interactive multimedia to improve the students' performance in Mathematics, specifically in the topic of matrices. The integration of cooperative learning, mastery learning, and interactive multimedia environment would provide a comprehensive framework needed for an effective and efficient teaching and learning of mathematical concepts. A computer-based systematically designed interactive courseware was created to test the hypotheses of this study. The effects on the gain scores and time-on-task would be investigated to determine the effectiveness of using the courseware in three different strategies, namely, Computer-assisted Mastery Learning (CML), Computer-assisted Cooperative Learning (CCL), and Computer-assisted Cooperative Mastery Learning (CCML). Students in the three learning strategies used the same instructional materials. The CML strategy was based on individual learning, while the CCML and CCL strategies were based on cooperative learning. Certain elements of mastery learning were added to the courseware, which were used in the CML and CCML strategies. The CCL strategy was based on cooperative learning and used the version of the courseware without the elements of mastery learning. The effects of the three learning strategies on the gain scores and time-on-task were investigated.

Research framework

This study examined the effects of the three learning strategies, which were measured using gain scores and time-on-task. The moderator variable was the academic ability. The dependent variables were the gain score and time-on-task. The relationship among the variables is depicted in Figure 1, describes the research framework of this study. As evidenced from the past social and cognitive psychology researches, academic achievement outcomes (gain scores) had been a significant variable in learning success within education classroom (Schwarz, 1998). In addition, many researchers (Schremmer, Hortz and Fries, 2001; Toh, 1998) used gain scores to investigate the effectiveness of treatment in instruction.

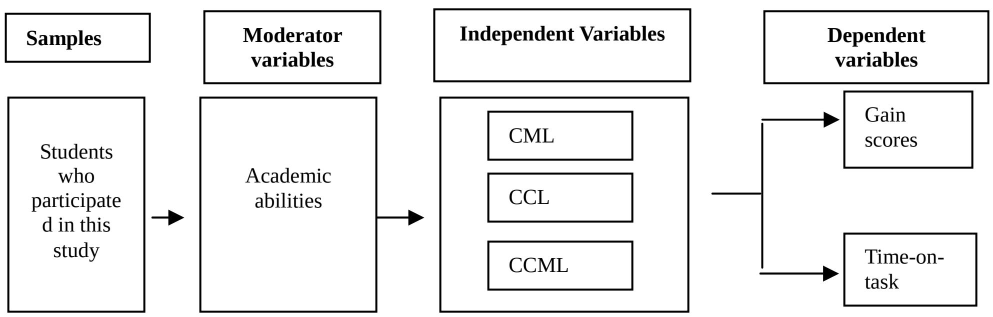

Figure 1. Research framework

Carroll (1989) emphasized that if a student really spent time in learning as needed, then he would achieve competence in learning. Bloom (1984) described that mastery learning would take more time than the normal teaching. With high quality instruction, a variety of methods were included that made learning easier for students to understand and remember. Thus, all students could learn differently with their individual abilities and work at their own pace through the planned sequence of lessons. It helped to motivate them to learn important concepts in order to proceed to the subsequent learning units. In this situation, the different academic abilities among learners would not affect their learning to a great extent. Mastery learning could be easily adapted to reduce achievement differences among students. Besides, time-on-task for a student could be shorter if an opportunity is given to a student to learn a learning unit through a series of quality instruction. With quality instruction, students would be more persistent in learning and increase their ability to understand the learning unit.

In mastery learning, students were grouped into high and low academic abilities. In this study, a standardized Mathematics examination results from the PMR examination (Penilaian Menengah Rendah, a standardized examination in Malaysia) were used to classify the students into high and low academic abilities. The examination gauges students' abilities after nine years of education in Malaysia. Therefore, it would be an accurate representation of students' mathematical abilities vis-à-vis the national norm as students could be classified into high and low academic abilities.

The followings are the hypotheses of this study.

H1 There are no significant differences in the dependent variables among 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.

H2 There are no significant differences in the dependent variables among students with high academic abilities in the CCL, CML and CCML strategies.

H2.1 There is no significant difference in the gain scores among students with high academic abilities in the CCL, CML and CCML strategies.

H2.2 There is no significant difference in the time-on-task among students with high academic abilities in the CCL, CML and CCML strategies.

H3 There are no significant differences in the dependent variables among students with low academic abilities in the CCL, CML and CCML strategies.

H3.1 There is no significant difference in the gain scores among students with low academic abilities in the CCL, CML and CCML strategies.

H3.2 There is no significant difference in the time-on-task among students with low academic abilities in the CCL, CML and CCML strategies.

Methodology

The design of this research is a quasi-experimental design. This study involved 262 students from four different secondary schools, namely schools *A*, *B*, *C* and *D*. Randomly, school *A* was assigned to the CCL treatment, school *B* and *D* was assigned to the CML treatment and school *C* was assigned to the CCML treatment. The number of students in CCL, CML and CCML were 77, 81 and 104 respectively.

The researcher had developed the courseware entitled "Matrices". Two sets of courseware were used in this study. The first courseware was designed with mastery learning elements, used in the CML and CCML strategies. The second courseware was designed without mastery learning elements, used in the CCL strategy. Before conducting the experiments, the courseware was field-tested for revision purposes.

The courseware was used as the instruction in those three groups, which were CCL, CML and CCML. Gain scores and time-on-task were used to investigate the effectiveness of the mentioned strategies. Before using the courseware, an entry test was conducted to filter students' basic knowledge in Matrices and determine whether they possessed the requisite prior knowledge on arithmetic, which involved addition, subtraction, multiplication and division of numbers (integers, fraction and decimal), and solution of one linear equation as well as two linear equations. A student's prior knowledge was considered high if he or she scored 80% and above. If a student scored less than 80%, then the student had to complete an interactive courseware program on arithmetic. The interactive courseware was specially created to strengthen those students' prior knowledge in matrices. Students had to obtain the required level of mastery before they could be given the treatment. Thus, before the actual commencement of the experiment, all samples in each group would have achieved the required prior knowledge.

The PMR Mathematics result was used to classify the students into different academic abilities. Students with Grade A and Grade B were grouped in the high academic ability category. Students with Grade C and Grade D were grouped in the low academic ability category.

The pretest and posttest questions were developed to determine students' understanding of important concepts related to Matrices. These tests, that consisting of 51 questions, had the reliability of 0.7051 based on the Kuder-Richardson Formula (KR20).

On the first day of the data collection, students were given a briefing on the learning strategies. Next, students were given a pretest on matrices and followed by a lesson on Matrices and Equal Matrices on the second day. After the lesson, students were given the first formative test using 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
(4) Identity Matrix, Inverse Matrix and solution of simultaneous linear equations by using Matrices.

The whole lesson took four to six hours to finish. Students took a test after each subtopic. The differences of three treatment groups in terms of presentation of the lessons, team function and individual improvement were as depicted in the following discussion. Students in the 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. At the end of a test, extra corrective activities were given to those who could not achieve the success level of 80% as evaluated by the computer.

Students in the CCL completed all activities in cooperative groups and they completed all tests independently. Students in the CCML completed all activities in cooperative groups and all tests were carried out independently for this group. Students who failed to meet the required performance level received supplementary instruction and correction activities immediately after each question until the requirement was met. At the end of a test, extra corrective activities were given to those who could not achieve the success level of 80% as evaluated by the computer. Each student needed to wait until all members in the group had achieved the level of 80%. Those who had finished and achieved 80% of the score were able to help other students who had not achieved 80% of the score. All the cooperative work was examined using checklist for the approach named Student Team Achievement Division (STAD).

The design of the courseware was based on a macro and micro design. Alessi and Trollip's instructional design model (Alessi and Trollip, 2001) was used for the macro design. Gagné's nine events of instruction (1985) was used for the micro design of the courseware. Motivational elements were incorporated into the courseware which was created based on Gagné's Motivational elements were incorporated into the courseware which was created based on Gagné's nine events of instruction.

Results

MANOVA was used with gain scores and time-on-task as the two dependent variables and the learning strategies (CCML, CML and CCL) as the group factor. Follow-up analyses would be conducted if the test on MANOVA was significant.

Gain scores and time-on-task for the three learning strategies

The descriptive statistics on the gain scores and time on task for CCL ($Gain_{CCL}$), CML ($Gain_{CML}$) and CCML ($Gain_{CCML}$) are shown in Table 1, where $Gain_{CCML} > Gain_{CML} > Gain_{CCL}$ and $Time_{CML} < Time_{CCL} < Time_{CCML}$.

Table 1. Descriptive statistics on gain score for CCL, CML and CCML

	CCL		CML		CCML		TOTAL	
	Gain scores	Time-on-task	Gain scores	Time-on-task	Gain scores	Time-on-task	Gain scores	Time-on-task
Mean	31.47	3.90	42.79	3.70	49.40	4.71	42.09	4.16
N	77	77	81	81	104	104	262	262
Std Dev	19.206	0.771	19.678	1.030	17.849	0.784	20.164	0.973

The results of the MANOVA test (Table 2) showed that the Wilk's lambda of 0.549 was significant, F = 45.032, $p < 0.05$. Thus, Hypothesis One, which stated 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 2. 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 are shown in Table 3. The univariate ANOVA for gain scores was significant, F = 20.155, p < 0.025. Likewise, the univariate ANOVA for time-on-task was significant, F= 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 3. 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				

The analyses revealed that there were significant differences in gain scores for the two pairs- CCML with CCL and CML with CCL. Also, there were significant differences in time-on-task for the two pairs- CCML with CCL and CCML with CML.

The effect sizes of learning strategies on the gain score

Effect sizes of CML and CCML towards CCL were studied because there were significant differences on gains scores between CML and CCL as well as between CCML and CCL. Calculations of the effect size (ES) of CML and CCML towards CCL are illustrated in Table 4. The results showed that the effect size of CML towards CCL was 0.5603, which was moderate. This indicated that an individual learner in CML had 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 4. The effect size of CCML and CML towards CCL

Learning Strategies	Difference of Means	Pooled Standard Deviation	Effect Size, *ES* $= \frac{\text{The Difference of Means}}{\text{Pooled Standard Deviation}}$
CML CCL	11.32	20.202	$ES = \frac{11.32}{20.202} = 0.5603$
CCML CCL	17.93	20.424	$ES = \frac{17.93}{20.424} = 0.8778$

The learning strategies effects on the dependent variables among students with high academic ability

The descriptive statistics on gain scores and time-on-task for CCL, CML and CCML of students with high academic abilities are illustrated in Table 5. For gain scores, the mean of CML ($Gain_{CML}$) and CCML ($Gain_{CCML}$) were close to each other, with the respective values of 53.49 and 52.52. Subsequently, CCL showed a lesser value in the gain scores ($Gain_{CCL}$) of 46.03. Thus, students with high academic ability obtained gain scores in the following sequence, $Gain_{CML} > Gain_{CCML} > Gain_{CCL}$.

Table 5. Descriptive statistics on gain scores and time-on-task among students with high academic ability

	Strategy	Mean	Std. Deviation	N
Gain Scores	Cooperative (CCL)	46.03	18.128	35
	Mastery(CML)	53.49	18.505	45
	Cooperative mastery(CCML)	52.52	16.254	92
	Total	51.45	17.372	172
Time-on-task	Cooperative(CCL)	3.46	.657	35
	Mastery(CML)	3.27	.780	45
	Cooperative mastery(CCML)	4.57	.684	92
	Total	4.00	.930	172

It can be seen in Table 5 that the time-on-task of CML and CCL are close to each other which were 3.27 hours ($Time_{CML}$) and 3.46 hours ($Time_{CCL}$) respectively. Subsequently, students in CCML spent longer time-on-task ($Time_{CCML}$), that was 4.57 hours.

Results of the MANOVA test (Table 6) showed that Wilk's lambda of 0.52 was significant, $F = 32.542$, $p < 0.05$. Thus, Hypothesis Two, which stated population means on the dependent variables among students with high academic ability were the same for the three groups, was rejected. The multivariate Eta Squared showed 27.9% of multivariate variance of the dependent variables was associated with the group factor.

Table 6. Multivariate tests of effect of learning strategies on the dependent variables among students with high academic ability

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Strategy	Wilks' Lambda	.520	32.542	4.000	336.000	.000	.279

A follow-up approach was conducted by using multiple univariate ANOVAs. Two ANOVAs were conducted, one for each dependent variable (i.e., gain scores and time-on-task). Results of the univariate ANOVAs are shown in Table 7. The univariate ANOVA for gain scores was not significant, $F = 2.221$, $p > 0.025$, but the univariate ANOVA for time-on-task was significant, $F = 64.214$, $p < 0.025$ and the associated Eta Squared was 43.2%. The results showed that there were significant differences in time-on-task for the two pairs- CCML with CCL and CCML with CML. Thus, Hypothesis 2.1 was not rejected and Hypothesis 2.2 was rejected.

Table 7. Univariate test of the effect of learning strategies on the dependent variables among students with high academic ability

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Gain Scores	1321.456	2	660.728	2.221	.112	.026
	Time-on-task	63.906	2	31.953	64.214	.000	.432
Intercept	Gain Scores	374873.704	1	374873.704	1259.938	.000	.882
	Time-on-task	2066.745	1	2066.745	4153.425	.000	.961
Strategy	Gain Scores	1321.456	2	660.728	2.221	.112	.026
	Time-on-task	63.906	2	31.953	64.214	.000	.432
Error	Gain Scores	50283.172	169	297.534			
	Time-on-task	84.094	169	.498			
Total	Gain Scores	506968.000	172				
	Time-on-task	2900.000	172				
Corrected Total	Gain Scores	51604.628	171				
	Time-on-task	148.000	171				

The learning strategies effects on the dependent variables among students with low academic ability

The descriptive statistics on gain scores and time-on-task for CCL, CML and CCML of students with low academic ability are shown in Table 8. For the gain scores, it can be seen that the mean of CML ($Gain_{CML}$) was the highest, which was 29.42, and followed by CCML ($Gain_{CCML}$) with the mean of 25.50. Mean of gain scores among students in CCL ($Gain_{CCL}$) were the lowest, which was 19.33. Thus, $Gain_{CML} > Gain_{CCML} > Gain_{CCL}$.

Table 8. Descriptive statistics on gain scores and time-on-task among students with low academic ability

	Strategy	Mean	Std. Deviation	N
Gain Scores	Cooperative (CCL)	19.33	8.913	42
	Mastery (CML)	29.42	11.111	36
	cooperative mastery (CCML)	25.50	9.625	12
	Total	24.19	10.909	90
Time-on-task	Cooperative (CCL)	4.26	.665	42
	Mastery (CML)	4.25	1.052	36
	cooperative mastery (CCML)	5.83	.577	12
	Total	4.47	.985	90

As shown in Table 8, time-on-task for CML and CCL are approximately equal which were 4.25 hours ($Time_{CML}$) and 4.26 hours ($Time_{CCL}$) respectively. It was observed that the mean of the time-on-task in CCML ($Time_{CCML}$) was the highest, which was 5.83 hours.

The results of the MANOVA test (Table 9) showed that Wilk's lambda of 0.527 was significant, F= 16.239, $p < 0.05$. Thus, Hypothesis Three, which stated that the population means on the dependent variables (i.e., gain score and time-on-task) among students with low academic ability were the same for the three groups, was rejected. The multivariate Eta Squared indicated that 27.4% of multivariate variance of dependent variables was associated with the group factor.

Table 9. Multivariate tests of the effect of learning strategies on the dependent variable among students with low academic ability

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Strategy	Wilks' Lambda	.527	16.239	4.000	172.000	.000	.274

A follow-up approach was conducted by using multiple univariate ANOVAs. Two ANOVAs were conducted, one for each dependent variable (i.e., gain scores and time-on-task). Results of the univariate ANOVAs are shown in Table 10. The univariate ANOVA for gain scores was significant, F = 10.093, $p < 0.025$ and the associated Eta Squared was 18.8%. Also, the univariate ANOVA for time-on-task was significant, F = 18.586, $p < 0.025$ and the associated Eta Squared was 29.9%. Thus, Hypothesis 3.1 and Hypothesis 3.2 were rejected.

Table 10. Univariate test of the effect of learning strategies on the dependent variable among students with low academic ability

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Gain Scores	1994.706	2	997.353	10.093	.000	.188
	Time-on-task	25.864	2	12.932	18.586	.000	.299
Intercept	Gain Scores	40861.522	1	40861.522	413.507	.000	.826
	Time-on-task	1525.236	1	1525.236	2192.021	.000	.962
Strategy	Gain Scores	1994.706	2	997.353	10.093	.000	.188
	Time-on-task	25.864	2	12.932	18.586	.000	.299
Error	Gain Scores	8597.083	87	98.817			
	Time-on-task	60.536	87	.696			
Total	Gain Scores	63251.000	90				
	Time-on-task	1882.000	90				
Corrected Total	Gain Scores	10591.789	89				
	Time-on-task	86.400	89				

Discussion

Generally, there were significant differences in gain scores between the learning strategies. The effect size in gain scores suggested that the CCML strategy had a more positive effect than the CML strategy. These results support the findings from past research that cooperative mastery learning produced better results (Akinsola, 1996; Krank and Moon, 2001; Laney, Frarich, Farich & Luke, 1996). Furthermore, these results are consistent with Mevarech's (1985) and Okebukola's (1985) findings that discovered positive effects of cooperative learning in the application of STAD approach and even better effects if it 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 are 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 organizing a systematic and more structured instruction to guide students for gaining high scores. In addition, incorporating cooperative learning could strengthen the role of mastery learning. This study also found that students in cooperative mastery learning groups were guided through well-designed instruction. Hence, better effect size was seen when the CCML strategy was used. These were consistent with Okebukola's (1985) findings that cooperative learning could strengthen students' performance. This study shows that the effect size of cooperative mastery learning was the highest in the gain scores and the effect was mainly contributed by mastery learning. The findings also support Mevarech's (1991) view that mastery learning had been successful in producing gains in achievement. There was a tendency to incorporate such programmes with cooperative learning strategies, which was called cooperative mastery learning (Mevarech, 1985).
Although mastery learning (systematic work) was the most important instructional method to make students succeed, it is better if supported by cooperative learning. This finding suggests that the advantages in cooperative learning were not obviously shown in the gain scores without mastery learning. This study shows that mastery learning plays a primary role and when incorporated with cooperative learning, students will learn more and systematically in the cooperative environment. Some students might be weak in the socialization and interaction skills and might need guidelines in mastery learning. Likewise, some students needed peer-guidance during the learning process. Thus, the CCML strategy was found to be the most effective learning strategy in this study.

In terms of time-on-task, the major finding is that students in the CML and CCL strategies spent shorter time-on-task compared to the CCML strategy. The results are consistent with past researches (Mortimore, and Sammons, 1987). According to Zimmerman (1998), there was an apparent correlation between time and achievement. The more time-on-task was made available to the student, the more activities and learning processes were involved. However, past literature suggested that even though time was certainly a critical factor but it had little direct impact on students' performance (Zimmerman, 1998). Simply adding time would not really produce large gains in student achievement. Rather, quality was the key to making time matter (Funkhouser, Humphrey, Panton and Rosenthal, 1995; Levin, 1985). Essentially, students should be provided with activities and instructions that catered to their needs and abilities, engaging them so they would continue to build on what they had learnt. What matters most were the valuable experience when students were absorbed in instructional activities that were adequately challenging, yet allowed them to experience success. This study has shown that the CML and CCML strategies could provide these experiences for the students.

For students with high academic abilities, the analysis showed that there were no significant differences in the gain scores among students with high academic ability in the CCL, CML and CCML strategies. The finding suggests that high academic ability learners could obtain high gain scores regardless of learning strategies. In many ways, students with high academic abilities were more alike in terms of the way they managed themselves in studies (Monaco, 2003). Students with high academic abilities were able to learn under any condition in the school, for example, small groups, alone and in informal settings. Thus, teachers could use any grouping pattern and instructional method as long as the method used could accommodate their teaching objectives.

This study also shows that there were significant differences in time-on-task across the learning strategies among students with high academic abilities. Students with high academic abilities in the CML and CCL strategies significantly spent shorter time-on-task compared to the CCML strategy. Therefore, the CCML students who were involved in using components of mastery learning and cooperative learning spent more time compared to those who were involved in either the mastery or the cooperative learning only. These findings indicated that there were no effects resulting from learning strategies among students with high academic ability. However, students with high academic abilities spent significant higher time-on-task on CCML without showing higher gain scores significantly. This result shows that cooperative learning provided a conducive structure for learning because students with high academic abilities were fully engaged to help other counterparts by clarifying misunderstandings and correcting learning errors to attain a criterion-referenced standard through a well-designed mastery learning instruction as revealed by Bork (1999). Therefore, students with high academic abilities in the CCML strategy showed significant higher time-on-task without showing higher gain scores.

For students with low academic abilities, the analyses reveal that there were significant differences on gain scores for CML and CCL. Also, there were significant differences on time-on-task for the two pairs which were CCML with CCL and CCML with CML.

The above results show that students with low academic abilities did not achieve significantly higher gain scores in the CCL and CCML strategies if compared to the CML strategy. This indicates that cooperative learning which was used in the CCL and CCML strategies did not give assistance to students with low academic ability. Additionally, within cooperative learning groups, students with low academic abilities did not influence each other's learning. Nevertheless, with the well-designed mastery learning instruction within a mastery learning environment, they could attain significantly higher gain scores compared to students in the CCL and CCML strategies. This could be interpreted within the context of the group processing concept in cooperative learning. According to Yager, Johnson, and Johnson (1985), the achievement of low academic ability students in cooperative learning environment also depended on how well their group was functioning.

In terms of time-on-task, the results were consistent with the results of students with high academic abilities, where students in CML and CCL significantly spent shorter time-on-task compared to CCML. Therefore, in terms of getting a higher gain score and shorter time-on-task, CML was the best learning strategies among students with low academic abilities. With the CML strategy, students' result increased within a shorter time compared to the students who used the CCML strategy.

Summary and conclusion

In conclusion, this study has led to the following key findings. Firstly, this study shows that the CCML and CML strategies are superior compared to the CCL strategy. Secondly, the CCML strategy is the best choice among the three learning strategies to obtain a higher gain score. However, for students with low academic ability, the CML strategy is found to be the best choice. This finding also suggests that high academic ability learners could obtain high gain scores regardless of learning strategies. Thirdly, in terms of time-on-task, students in CCL and CML strategies demonstrated significant lower time-on-task than CCML strategy.

The findings of this study propose a simple yet powerful approach to facilitate the learning process of students through the use of a multimedia integrated learning system with a series of high quality instructions in cooperative mastery learning and mastery learning.

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